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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CVII.—No. 2790.] *LONDON: FRIDAY, JUNE 20, 1919.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...9d. BY INLAND POST ... 11d.

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4078

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Boilers.
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6877
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See Full Page Advt., page 32, May 30.

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See Advertisement page 7. 2402

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See Full Page Advertisement, May 30.

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See half-page Advert. last week and next week. 7528

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7006
See half-page Advertisement page 107, June 13.

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TENDERS.

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BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

GENERATING SETS and OIL PUMPING PLANT at BARRY Ddocks. (I.W. & D. TRANSIT SHED.)

FOR SALE BY PUBLIC TENDER.

Tenders are Invited for the PURCHASE, as a whole or in part, of the undernoted:—

GENERATING SETS.

Two 5 KW. Rational Siemens oil-driven, direct-coupled generating sets for 220 volts d.c., complete with switchboards, cooling tanks, &c.

Three 10 KW. Ditto

FUEL OIL PUMPS.

Four Horizontal belt-driven duplex pumps, capacity 3500 gallons per hour against 100 lbs. pressure.
(Horse-power required to drive above—8.)
Six ditto. Capacity 4000 gallons per hour against 100 lb. pressure.
(Horse-power required to drive above—12).
One ditto, Capacity 6500 gallons per hour against 100 lb. pressure.
(Horse-power required to drive above—20).

Above Pumps are all fitted with brass lined cast-iron barrels, fast and loose belt pulleys and striking gear.
Set of spare parts with each pump.
ALL ITEMS ARE NEW AND UNUSED.
Tenders to be made on Official Form and lodged not later than 10 a.m. on 1st July, 1919.
Application for Tender Forms and Permits to view to be made to CONTROLLER, D.B. 1 (M), Charing Cross Embankment Buildings, W.C. 2. W 526

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

NEW OFFICE FURNITURE FOR SALE BY TENDER.

Tenders are Invited for the PURCHASE of a QUANTITY of NEW OFFICE FURNITURE, &c., comprising:—

COLLAPSIBLE TABLES,
4 ft. 6 in. by 5 ft. and 10 ft. long, with and without drawers, in deal, stained or varnished, or in white.
COLLAPSIBLE FORMS,
5 ft. and 6 ft. long, in deal, left in the white.
STORE CUPBOARDS,
3 ft. by 4 ft. and 6 ft. wide, fitted shelves, in deal, stained and varnished.
PLAN OR MAP PRESSES,
eight drawers, double elephant size, in deal, stained and varnished.
DWARF CUPBOARDS,
3 ft. 3 in. wide by 2 ft. 7 in. high, fitted centre vertical division and shelf, in deal, stained and varnished.
STATIONERY OR TYPISTS' CUPBOARDS,
11 in. wide by 2 ft. 4½ in. high, fitted 11 removable shelves to take foolscap size paper, in deal, stained and varnished.
VERTICAL FOOLSCAP FILING CABINETS,
two drawers in deal, stained and varnished.
CARD INDEX BOXES AND CABINETS,
for cards 5 in. by 3 in., 6 in. by 4 in. and 8 in. by 5 in.; boxes in deal with ply-wood lids; cabinets in solid oak.

The whole of the Furniture is of sound construction and is quite new (unused).
Tenders should be for a minimum quantity of £100 (one hundred pounds) value, and will be received up to 10 o'clock a.m., on Friday, June 27th.
A sample of each article can be seen upon application to the Disposal Board's Sample Room, at H.M. Office of Works, King Charles Street, Whitehall, S.W. 1.
Full particulars, Tender Forms, &c., can be had on application to the CONTROLLER (FURNITURE SECTION), DISPOSAL BOARD, 16, Queen Anne's Gate, Westminster, S.W. 1. W 554

TENDERS.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, &c., are prepared to receive

Tenders before Eleven

a.m., on FRIDAY, the 27th JUNE, 1919, addressed to THE SECRETARY, H.M. Office of Works, &c., Storey's Gate, Westminster, London, S.W. 1, for the SUPPLY of WIRE LIFT ROPE (during a period of six or twelve months from date of acceptance of Tender).
Forms of Tender, &c., may be obtained on application to the CONTROLLER OF SUPPLIES, H.M. Office of Works, &c., King Charles Street, Westminster, London, S.W. 1. W 575

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

500 HP. DIESEL ENGINE.

For Sale, by Public Tender,

One only 500 HP. "Diesel" Engine (New), with SPARE PARTS and ACCESSORIES, by Mirrless, Bickerton & Day.
Now lying at maker's works, Hazel Grove, near Stockport.
Tenders for above will be received up to 10 a.m. on 30th June, 1919.
Tender Forms and Permits to view can be obtained from THE CONTROLLER, M.P. (D) Section, Charing Cross Embankment Buildings, W.C. 2. W 413

ALFRETON URBAN DISTRICT COUNCIL.

TO MAKERS OF BORE-HOLE PUMPS.

The above Council is prepared to receive

Tenders for Supplying and FIXING at Blakelow, in the parish of Ashover, Derbyshire, a BORE-HOLE PUMP of 10 in. diameter.

Particulars may be obtained of the undersigned.
Sealed Tenders, endorsed "Bore-hole Pump," accompanied by specifications and prints, to be delivered at my office not later than Monday, July 7th, 1919.
The Lowest or any Tender not necessarily accepted.
R. F. WARD,
Council Offices, Water Engineer.
Alfreton. W 580

COUNTY COUNCIL OF MIDDLESEX.

TO CONTRACTORS.

GREAT WEST ROAD.

CONTRACT No. 1.

The County Council of Middlesex invite

Tenders for the Work and MATERIALS REQUIRED in the Construction of the First Section (a length of about three miles) of the proposed new Great West Road, and a new spur road and widening, about 700 yards long, with other contingent works of bridge construction, &c.

The Great West Road, will be 80 feet wide, between fences (with cuttings and embankments), and included in the Contract there will be:—

(a) About 13 miles of soil and surface water sewers;
(b) „ 350 cylindrical manholes; and
(c) „ 11 subways for gas and water mains.

The Plans, Sections, Specification of Works, and Conditions of Contract, prepared by me, may be seen, and Bills of Quantities obtained, at my Offices by intending Contractors (on payment of Twenty Guineas, which will be returned on receipt of a bona-fide Tender), on, and after, July 10th, 1919.
Tenders, endorsed "Great West Road—Contract No. 1," to be delivered, in sealed envelopes, to the Clerk of the County Council, Middlesex Guildhall, Westminster, S.W. 1, not later than Twelve o'clock on MONDAY, JULY 28TH, 1919.
The lowest or any Tender will not necessarily be accepted.
H. T. WAKELAM,
Middlesex Guildhall, M.Inst.C.E.,
Westminster, S.W. 1, County Engineer.
12th June, 1919. W 578

COUNTY OF WEST SUSSEX.

NORFOLK BRIDGE OVER RIVER ADUR, SHOREHAM-BY-SEA.

TO BRIDGEWORK CONTRACTORS.

The West Sussex County Council is prepared to consider

Tenders for the Entire RE-CONSTRUCTION of the SUPERSTRUCTURE of the above Bridge under the West Sussex County Council (Bridges) Act, 1918, 8 and 9 Geo. V., c. XLI., together with the Partial Reconstruction of both Abutments, the provision of one new Pier, and the possible strengthening of two existing Piers.

The new super-structure will consist of four Bow String Girders, having an approximate total length of 350 ft., the roadway being 18 ft. in width and having two cantilever paths.
Plans, Specifications, and Bills of Quantities may be seen at the Offices of the Consulting Engineer to the County Council, Mr. H. HOWARD HUMPHREYS, 281, Victoria Street, Westminster, S.W. 1, between the hours of 10 a.m. and 4 p.m. on and after Monday, June 23rd, 1919, and up to June 28th.
Contractors requiring Specifications and Quantities will be able to obtain the same by depositing Ten Guineas with the above-named Consulting Engineer, such sum will be refunded on receipt of a *bona fide* Tender.
The successful Contractor will be required to execute a contract deed as prepared by the undersigned, the draft of which may be inspected at the Offices of the Consulting Engineer.
Tenders must reach the undersigned not later than Four p.m., on Saturday, July 12th next, marked "Norfolk Bridge Tender" on the outside of the envelope.
The County Council does not bind itself to accept the lowest or any Tender.
Dated the 11th day of June, 1919.
S. THORNELEY,
Clerk of the West Sussex County Council.
51, East Street,
Horsham. W 516

PARISH OF WILLESDEN.

The Guardians of the Poor of the above-named Parish invite

Applications from Engineering FIRMS WILLING TO TENDER to the plans and specification of their Consulting Engineer, Mr. W. M. BINNY, A.M.I.C.E., for Alterations to the Heating and Hot Water Supply System at the Willesden Institution, Acton Lane, Willesden.

Applications, with list of similar works executed, to be made on or before June 23rd, 1919, by letter to—
J. HUTTON HAYLOR,
Clerk to the Guardians.
359, High Road, Brondesbury, N.W. 6.
June 10th, 1919. W 474

CEMENT.

The MUNICIPALITY OF BOMBAY invite

Tenders for the Supply of 3000 CASKS of PORTLAND CEMENT to fulfil the requirements of the British Standard Specification and to be delivered f.o.b. at an approved port.

Forms of Tender may be obtained at the Offices of SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, the Consulting Engineers and Agents of the Municipality, 2, Queen Anne's Gate, London, S.W. 1.
Tenders, endorsed "Tender for Cement," must be addressed to the Consulting Engineers and Agents as above and delivered before noon on Friday, 27th June, 1919.
The lowest or any Tender will not necessarily be accepted. W 662

URBAN DISTRICT COUNCIL OF FELIXSTOWE AND WALTON.

Tenders are Invited for the PURCHASE of the following, which can be viewed, by appointment, at Felixstowe:—

Two O.H. size Horizontal Stockport GAS ENGINES, piston 12 in. dia., 18 in. stroke, each fitted with two extra heavy fly-wheels, sensitive governor, electric and tube ignition, speed 210 r.p.m.
Two 4 pole shunt-wound GENERATORS, 20 Kw. each, speed about 900 r.p.m., 200-230 volts with slide rails.

Tenders should be addressed to the CLERK to the Urban District Council, at the Town Hall, Felixstowe. The machines will be dismantled by the staff of the Generating Station, and delivery will be given on the generating station site.
The Council do not bind themselves to accept the highest or any Tender. W 691

CITY OF BRADFORD.

SEWAGE DISPOSAL WORKS.

STEAM DRIVEN AIR COMPRESSOR (Contract No. 27).

The Corporation are prepared to receive

Tenders, for the Supply, DELIVERY and ERECTION of ONE STEAM-DRIVEN AIR COMPRESSOR; capacity 1000 cubic ft., 100 lb. pressure.

Further particulars may be obtained at the Office of Mr. JOSEPH GARFIELD, M.Inst.M.E., Beholt Hall, Shipley (Station, Apperley Bridge, Mid. Ry.).
Tenders, endorsed "Sewage Disposal Works—Contract No. 27," must be delivered at the Office of the undersigned, not later than Twelve o'clock noon, on MONDAY, 7th JULY, 1919.
The Coporation do not bind themselves to accept the lowest or any Tender.
FREDERICK STEVENS,
Town Hall, Town Clerk.
Bradford,
June, 1919. W 633

CITY OF BRADFORD.

SEWAGE DISPOSAL WORKS.

SEWAGE EJECTORS (CONTRACT No. 28).

The Corporation are prepared to receive

Tenders for the Supply, DELIVERY, and ERECTION of THREE EJECTOR CYLINDERS, 1,400 galls. total capacity; with air receiver, air mains, and all necessary pipes, valves, &c., complete.

Further particulars and copies of Specification may be obtained at the Office of Mr. JOSEPH GARFIELD, M.Inst.C.E., Beholt Hall, Shipley (Station, Apperley Bridge, Mid. Ry.).
Tenders endorsed "Sewage Disposal Works, Contract No. 28), must be delivered at the Office of the undersigned, not later than Twelve o'clock noon, on MONDAY, 7TH JULY, 1919.
The Corporation do not bind themselves to accept the lowest or any Tender.
FREDERICK STEVENS,
Town Hall, Bradford, Town Clerk.
June, 1919. W 639

PORT OF BRISTOL.

INSULATION OF COLD STORES, ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee invite

Tenders for the Insulation of the COLD STORES now in course of construction at the Royal Edward Dock, Avonmouth.

On and after Thursday next, the 19th inst., a copy of the Form of Tender, General Conditions, Specification, Schedule of Prices, and a copy of the Contract Drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the Secretary of the Docks Committee, to whom all cheques must be made payable. The deposit of £5 will be returned hereafter to all *bona fide* tenders.
The Specification is based on part slab cork and part silicate of cotton insulation, but firms may tender on slab cork insulation throughout.
Tenders must be enclosed in a sealed envelope, endorsed "Tender for Insulation of Cold Stores, Royal Edward Dock," and addressed to the GENERAL MANAGER and SECRETARY of the Docks Committee, Docks Office, 19, Queen Square, Bristol, and must be delivered to him, accompanied by the prescribed documents and drawings, before Ten a.m. on Thursday, the 10th day of July, 1919.
THOMAS A. PEACH,
Engineer.
Engineer's Office,
Avonmouth Docks,
16th June, 1919. W 644

BELFAST HARBOUR.

The Belfast Harbour Commissioners are prepared to receive

Tenders for the Construction, SUPPLY and ERECTION on the Quays at Belfast Harbour where pointed out, of THREE ELECTRIC TRAVELLING GANTRY CRANES, each designed and constructed for a working load of FIVE TONS.

An Alternative Tender is to be submitted for FIVE CRANES to the same specification.
Specification, form of tender, and any further information required may be obtained from the HARBOUR ENGINEER, Mr. T. S. GILBERT, M.Inst.C.E.
Sealed Tenders on the special form provided for the purpose should be addressed to the undersigned, endorsed "Tender for Electric Cranes," and sent in, on or before Wednesday, the 30th July, 1919.
The Commissioners do not bind themselves to accept the lowest or any Tender.
D. J. OWEN,
Secretary.
Harbour Office,
Belfast.
12th June, 1919. W 567

APPOINTMENTS OPEN.

A Large Firm of Engineers in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of ENGINEERING.

STAFFORDSHIRE EDUCATION COMMITTEE. BRIERLEY HILL HIGHER EDUCATION COMMITTEE.

Applications are Invited for the POST of HEAD MASTER of the Technical School, Brierley Hill, South Staffordshire. Experience in teaching and acquaintance with the Iron and Steel Trades, or with the Chemistry of Refractory Materials desirable.

Initial salary, £300 a year.
Further particulars and forms of application may be obtained from the undersigned. Applications must be received not later than 30th June, 1919.
GRAHAM BALFOUR,
Director of Education.
County Education Offices, Stafford.
June, 1919. W 330

UNIVERSITY OF CAMBRIDGE.

VACANCY IN THE UNIVERSITY LECTURESHIP IN THERMODYNAMICS.

The General Board of Studies will shortly proceed to

Appoint a University Lecturer in THERMODYNAMICS, to hold office from 1st October, 1919, to 30th September, 1922. The annual stipend is £100. The Lecturer will also receive from the funds of the Engineering Department a sum amounting probably to about £400 a year.

Candidates are requested to send their applications, with such testimonials as they think fit, to the VICE-CHANCELLOR of the University of Cambridge, on or before July 1st, 1919. W 593

MUNICIPAL TECHNICAL COLLEGE, GUILDHALL, BATH.

PRINCIPAL—A. GODFREY DAY, A.M.I.Mech.E.

Required in September:—

(1) ENGINEERING MASTER for Machine Drawing, Mechanics, and other Engineering subjects.
(2) SCIENCE MASTER, for Physics, Chemistry, &c.

Scale salary (in each case): Graduates or equivalent, £140 to £280; Non-graduates, £120 to £250, by annual increments of £10. Initial salary according to qualifications and experience.—For particulars, apply at once to the PRINCIPAL. W 597

THE BRITISH COTTON INDUSTRY RESEARCH ASSOCIATION.

APPOINTMENT OF DIRECTOR OF RESEARCH.

The Committee of Management of the above Association invite

Applications for the Post of DIRECTOR OF RESEARCH, at a salary that will depend upon the qualifications of the successful Candidate, but that will not be less than £1250, and may considerably exceed that sum.

Applications must be received on or before 21st July, 1919.
Forms of application and all information may be obtained from:
THE SECRETARY,
BRITISH COTTON INDUSTRY RESEARCH ASSOCIATION,
108, Deansgate, Manchester. W 600

CITY OF LIVERPOOL.

ENGINEER AND CHIEF SUPERINTENDENT OF BATHS AND WASHHOUSES.

The Baths Committee of the Council of the City of Liverpool invite

Applications for the Appointment of ENGINEER and CHIEF SUPERINTENDENT of Baths and Washhouses at a salary of £540 per annum and War Bonus. The age of Candidates must not exceed 45 years (officials excepted), and the gentleman appointed will be required to devote his whole time to the duties of the office. Candidates for the position must have a practical knowledge of engineering, construction of buildings and machinery.

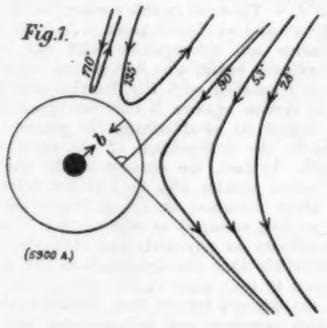
Applications, accompanied by copies of not more than three recent testimonials, endorsed "Engineer and Chief Superintendent of Baths and Washhouses," and addressed to the Chairman of the Baths Committee, under cover to the Town Clerk, Municipal Buildings, Liverpool, must be delivered not later than the 30th June, 1919.
Canvassing of members of the Council will be regarded as a disqualification.
List of duties may be obtained on application to the Baths Department, Municipal Offices, Liverpool.
EDWD. R. PICKMERE,
Town Clerk's Office, Liverpool. Town Clerk.
17th June, 1919. W 622

ATOMIC PROJECTILES AND COLLISIONS.

THE session of the Royal Institution was closed on June 6 with a discourse on radiations and atomic structure, subjects which have been prominent during recent sessions and which, indeed, domineer in physical and chemical science. The title was "Atomic Projectiles and their Collisions with Light Atoms," and the lecturer was Sir Ernest Rutherford, F.R.S., of Manchester, who next autumn will take up his duties as Cavendish Professor of Physics in Cambridge; Sir J. J. Thomson resigned this chair before Easter. The discourse gave plenty of food for reflection.

In his introduction, Sir Ernest dwelt upon the enormous energy of moving α and β particles, the most concentrated source of energy known. We had evidence of that energy when we saw the brilliant flash of light produced by an α particle striking a screen of zinc sulphide, and when we examined the dense distribution of ions along the path of an α particle through a gas on C. T. R. Wilson's photographs. But we did not realise what the energy meant in relation to the mass in motion. The swiftest α particles were ejected from radium C with a velocity of 19,000 km. per second. If we could obtain an ounce of helium moving at the speed of the swiftest shell, 1 km. per second, the ounce of helium would have an energy corresponding to 10,000 tons of solid shot projected at 1 km. per second.* When we shot a swift α particle through matter, we should anticipate that the atom —assumed to be a system of positive and negative particles—would deflect the moving particle, and a pencil of α particles striking a thin sheet of gold, *e.g.*, was indeed scattered and came out as a divergent beam, like a ray of light passing through a turbid medium; Sir Ernest demonstrated this optical analogue.

The full explanation of the scattering was not so simple, however. Geiger and Marsden had observed that a few particles—but only a very few—came straight back from the surface they hit, and that was a very remarkable fact considering the enormous



energy they carried; shell did not come straight back from the target. Such deflections through nearly 180 deg. and other angles could only be understood if the atom were itself the seat of extraordinarily intense forces, and in order to explain these phenomena Sir Ernest had put forth his own modification of the "nucleus atom." His atom consisted of a positive charge concentrated in a very small nucleus—increasing in size with the atomic weight—surrounded by one or more rings of electrons. In that atom the distances between the nucleus and the electrons would be great, compared to the nuclear dimensions, and when an α particle was fired at the centre, the electrons of the system might be disregarded. It could easily be shown that the repulsion between the positive charges of the nucleus and of the α particle (the projectile) would arrest and deflect the latter and cause it to describe a hyperbolic curve. The projectile would not be able to penetrate into a certain region immediately around the nucleus; but the approach might be very close, before the projectile was turned off at angles of 170 deg., 135 deg., 90 deg., 35 deg. and 28 deg., as indicated in Fig. 1.

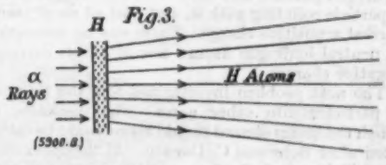
In order to demonstrate these effects, Sir Ernest had suspended an electromagnet (a bar) as a pendulum by a long cord above another vertical bar magnet, on the top of which a red ball had been placed to represent the nucleus; in the two magnets north faced north. When Sir Ernest let the pendulum go, it described curves like those of Fig. 1, the deflections from the original path being smaller when the motion was faster; when held close to the ball (within the zone of intense repulsion) and then released, the pendulum was at once deflected. Among experimental verifications, Sir Ernest mentioned in the first instance the ionisation experiments of Wilson [already referred to]. The track (Fig. 2) of the α particle through moist air was built up of multiples of water drops condensed upon the ions of atoms; two deflections could be noticed in the (upper) trail shown; the little back-

FIG. 2.

ward projection at the sharp corner marked the recoil of the oxygen atom to which the lecturer referred later. Such marked deflections, Sir Ernest added, were not always noticeable.* When a particle was fired at a nucleus, the chances of a head-on collision were obviously very remote; the collision was more likely to be glancing or oblique, and hence the numbers of α particles scattered through small angles was very much larger than the numbers of widely-scattered particles. To impress this point upon his audience, Sir Ernest exhibited a diagram, on which the ratio of the numbers of particles scattered through small and large angles were represented by lines ranging from centimetres to kilometres in lengths. The numbers were obtained by Geiger and Marsden by counting the numbers of scintillations produced on a screen of zinc sulphide by the α particles passing through a thin sheet of gold, silver or other materials. The results of Sir E. Rutherford's recent investigations, we should say, are largely based upon this method of counting the scintillations; it is done with the aid of a microscope, of course, and the field of view has a diameter of 2 mm. Sir Ernest had stated on another occasion that such counting cannot be continued for more than an hour per day and can only be repeated on a few days in a week. Geiger and Marsden found for gold deflections of 150 deg., 120 deg., 75 deg., 45 deg., 30 deg., 15 deg., the scintillation numbers N = 33, 52, 211, 1435, 7,800, 132,000. Assuming that the repulsion followed the law of inverse squares even for the minute distances within the atom, the term $N/\sin^4\phi/2$ (where ϕ was the angle of deflection) should be a constant; the figures stated agreed with that constancy within about 30 per cent. Considering the difficulties of the method, Sir Ernest remarked, that agreement was sufficiently satisfactory. Again, experimenting with α particles of different velocities v, the product $N v^4$ should be constant, and it was found to be fairly constant. These experiments, Sir Ernest considered to be of fundamental importance, in these troublesome times when people were inclined to leave their old faith in the inverse square law. That law had generally been verified for distances of the order of a centimetre; here it was found that it held for distances of 10^{-11} cm., and the observations would not conform with any other law. If, then, the inverse square law were obeyed within regions so close to the atomic centre, it might be taken for granted that it would hold generally for these very minute distances which, however, were large compared with the dimensions of the nucleus.

Passing to collisions between α particles and atoms, Sir Ernest said, we should anticipate the ordinary laws of impact to apply to such collisions as well as to the collisions of billiard balls. His balls were pendulums, suspended by strings. When a light ball struck a heavy ball, the light ball (atom of small mass or light atom, hydrogen) rebounded nearly through the full arc, whilst the heavy ball (α particle, helium atom) scarcely moved—head-on collision presumed. When the conditions were reversed, the heavy ball striking the light ball, they both travelled on after the impact, the light ball going at the faster rate. Sir Ernest said that he had been able to verify this law of impact for hydrogen, working, during part of the wary ears, together with Professor Marsden (who had now returned to New Zealand) and with his assistant, Mr. William Kay. The hydrogen atom hit by the α particle acquired 1·6 times the velocity of the latter and could be traced through four times the distance (range) which the α particle would travel. The experiments were made in a box, filled with the respective gas at variable pressures, and closed at one end by ground glass, and at the other by a brass plate with a central opening; the opening was fitted with a window of some metal, and outside that window, 1 mm. or 2 mm. off, was the zinc sulphide screen, the scintillations of which were counted. His source of α particles had first been a thin-walled glass tube filled with emanation, later a disc of copper, about the size of a 6*d.* piece, previously exposed to emanation (equivalent to 10 milligrammes of radium and more), and mounted in the box. These radiations would, after a while, be much more homogeneous than with emanation itself. In the box the α particles shot through the hydrogen and sent the hydrogen through the window on to the screen; the α particle itself would be stopped by the window (the stopping power of which was equivalent to about 5 cm. of air) if not before by the gas in the box, the length of which was 18 cm.

Discussing first the results to be expected, Professor Rutherford pointed out that, assuming that the nuclei of the α particles and of the hydrogen atoms would both be point charges subject to the law of inverse squares, the scattering of the struck H atoms should be such that only the very small number hurled nearly in the direction of the striking α particles would travel their full range, at full



velocity, whilst the much larger numbers of H atoms, scattered so as to form greater angles with the direction of the α particle, should come to rest within much shorter ranges. For swift α particles of a range of 7·7 cm. (in air) the maximum range of the struck H atoms should be 28 cm. But the actual observations indicated that most of the H atoms attained the full range; the scattering was hence not the anticipated scattering; it seemed to be rather as represented in the diagram, Fig. 3, where α particles strike a partition wall of H atoms and drive them out nearly in their own direction with very little scattering. The probable explanation was that in these collisions the nuclei approached one another within 3×10^{-13} cm., *i.e.*, much closer than in the cases so far considered (of α particles and gold, &c.). The billiard ball analogue would be that three or more small balls, suspended close to one another (three H atoms), were simultaneously hit by one large ball (an

* These are the exact words we understood Sir Ernest to use.

* Our Fig. 2 is reproduced from the discourse by Mr. C. T. R. Wilson on "Photographs of Particles Ejected from Atoms," ENGINEERING, March 14, 1913, page 363. Sir Ernest Rutherford exhibited the upper curve; the lower, it will be seen, is practically straight almost to the end.

α particle represented by a heavy disc in the demonstration); all the three balls flew off together at the same speed. That, Sir Ernest added, applied to the swiftest α particles of 7 cm. range. As the velocity of the incident α particles was lowered, however, from range 7 cm. to 4 cm. and less, the experimental absorption curve of hydrogen atoms approached more and more the anticipated theoretical curve.

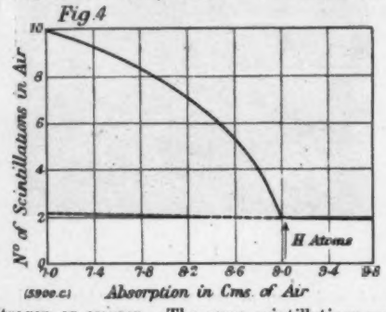
There seemed thus to be one law of absorption and of scattering for swift particles and another for slow particles, and there were other anomalies to account for. The number of H particles [counted by scintillations, as mentioned] was decidedly greater than it ought to have been. Now the helium atom or α particle might be represented by four hydrogen nuclei, together with two electrons, all in one plane, the nucleus being a disc of radius $3{\cdot}6 \times 10^{-13}$ cm. When such a system was approached within distances comparable to the dimensions of the nucleus, the configuration of the forces would change, and the simple laws of point charges would be departed from, as we should expect. The forces between the Earth and Moon were not now the same as they had been when the two were much closer to one another in ages past. Colossal forces would be involved in the collisions spoken of, the force might change from repulsion to attraction, and the whole system would be deformed. The law of inverse squares need not hold for extremely close approach. What surprised the lecturer was how, with such gigantic forces, the atom could survive a collision. The fact of its surviving was a proof that the structure of the α particle or its nucleus must be very stable indeed. He had been searching for débris of helium atoms; so far he had not obtained any certain evidence of such a destruction, but there was some evidence. In any case, there must be deformation of the system; that would not invalidate the nuclear theory or the atom, but if we could get close enough, we should expect similar deformation with gold.

Sir Ernest next spoke of the experiments made to decide whether his supposed hydrogen atoms shot out were really hydrogen atoms. He mentioned first in this connection that his hydrogen wall of Fig. 3 was not a mass of hydrogen gas, but a thickness of paraffin, a hydrocarbon. Chemists might ask what happened when a molecule of a compound, and not an atom, was hit. But to the colliding particle it did not matter whether the hydrogen was the gas, or the molecule or atom of a compound; the hydrogen would be expelled as if it were free, and we could determine in this way, whether there was hydrogen in a substance. The determinations were made by measuring the deflection of the atoms by magnetic and electrostatic fields, and the results were in accord with the view, that the hydrogen particle travelled 1·6 times as fast as the α particle colliding with it, and that all these atoms carried a positive charge. There was no indication of neutral hydrogen atoms, nor of atoms carrying negative charges.

The next problem investigated was the firing of α particles into other gases. The distances to which the atoms ejected should travel could be calculated after Bohr and C. Darwin. If the atom after the collision carried a charge of two units, its range should be only one-fourth that of the same atom carrying a single charge. The helium atom, possessing itself the same mass as the α particle and two charges, should stop the α particle and go on with the velocity of the α particle, according to the law of impact, and that was confirmed; if the helium atom carried one charge only, its range should be four times greater. If carrying two charges, the hydrogen atom H should have the same range as helium; if carrying one charge, four times that range. The hypothetical hydrogen compounds H_2 and H_3 would have slightly greater ranges in either case than the H and H_2 (if endowed with one charge) and should have the maximum range, five times as large as the helium range. The ranges of all the other elements would be smaller and become very small indeed for the heavy metals of higher atomic weights. In the diagrams which Professor Rutherford exhibited the elements were arranged in the order of their atomic weights. Some work had been done on salts of lithium (atomic weight 7), beryllium (9) and boron (11); but for heavier atoms, beyond neon (20), the experimental research, the range determination, seemed almost hopeless. There was the additional difficulty that the substances investigated might contain hydrogen, and further that a small irregularity in the thickness of a metal sheet would make a great difference.

Some curious observations had been made in the study of the collisions of α particles with nitrogen, oxygen and air. In some of these experiments the radium disc and the screen mentioned were both mounted in the open air, 7 cm. or more apart. Bright scintillations were observed, whilst the scintillations due to hydrogen were faint; there had hence been some suspicion of these scintillations being due to α particles themselves, but that was disproved. Fig. 4 is one of the diagrams shown; the ordinate marks the number N of scintillations on an arbitrary scale. The N dropped off decidedly as the absorption increased to 9 cm.; scintillations observed at greater range were probably produced by hydrogen—a point, presently to be discussed—but up to 9 cm. they seemed to be due to either

Fig. 4



nitrogen or oxygen. The same scintillations were further observed in carbon dioxide, and as carbon atoms carrying only one charge were not known, they had in that case to be attributed to oxygen. The length of the spur in Wilson's trail (Fig. 2) was also very nearly of the length which the recoil of the oxygen atom required. It was clear from these results that the nuclei under consideration could no longer be regarded as point charges for distances of approach of the order of the diameter of the nucleus. So far only a rough estimate could be made of the distances at which the forces became abnormal. In the case of oxygen the rapid variation in the magnitude and direction of the forces between the nuclei which led to the recoil of swift atoms, should begin at about 7×10^{-13} cm.; that result might be anticipated on general grounds; for the oxygen nucleus was probably of larger dimensions and more complex than the helium nucleus.

But the scintillations observed seemed to suggest that hydrogen in some way made its appearance during the course of the experiments. Hydrogen might be present as accidental impurity, or as water vapour; it might be liberated from the bombarded metal screens which retain gases, and it might finally be a transformation product of the radioactive source RaC. That problem was not solved yet. Special experiments were therefore made in the box described; the box was exhausted and then filled with various gases. On admitting oxygen the number of scintillations diminished; in carbon dioxide it likewise dropped, the limiting range being in both cases that of hydrogen, 28 cm.; in nitrogen and in dry air, however, the number of scintillations increased, to two or three times the value it had in the absence of nitrogen. Why did nitrogen differ from oxygen and carbon dioxide? It looked as if the effect were due to nitrogen; but the range was again that of hydrogen (28 cm.), not the nitrogen range (9 cm.). Drying the gas had no noticeable effect; the rare gases might be responsible, but specially-prepared chemical nitrogen behaved like atmospheric nitrogen. Heating the electrode to expel any gases retained by them made no difference; dust particles did not appear to be concerned either. Thus Sir Ernest seemed forced back to the supposition that the scintillating particles consisted either of hydrogen itself, or possibly of the hypothetical H_2 or H_3. To discriminate between these would require special magnetic and electrostatic deflection experiments, and in view of the narrowness of the slit needed and the small number of particles actually concerned, something like half a gramme of radium would be wanted and such experiments did not look promising.

The hydrogen in question, H or H_3, would not be ordinary hydrogen, however. It would really come, Sir Ernest remarked in concluding his discourse, from nitrogen and would represent a disruption product of the nitrogen nucleus. One could imagine such an effect, if the nitrogen nucleus, atomic weight 14, consisted of three helium nuclei ($3 \times 4 = 12$) plus two hydrogen nuclei ($2 \times 1 = 2$), or one nucleus of mass 2 (H_2); the electrons would be far away from this nucleus. That helium formed a unit of the elements was assumed for other reasons as well. If an α particle collided with such a complete nucleus, it would not strike a hydrogen atom as easily as it would if the atom were all built up of hydrogen; thus H atoms would only rarely be detached by these collisions. The suggestion was highly speculative. It did not mean that nitrogen was not an element; it was an element in a particular condition. Sir Ernest added that he had not been counting hydrogen scintillations for the fun of the thing. He had all the time been looking out for disruptions of nuclei by high-speed particles, and it would be an excellent thing if some one could grow particles of, say, 700 cm. range, instead of 7 cm. We might then break down some of the lighter atoms at any rate. Sir Ernest wished to start on a systematic examination of these atoms. The heavier atoms promised little in this respect, since the α particles were not swift enough to get sufficiently close to the nucleus to effect disruption.

Our readers may remember that, lecturing before Easter in the same place, Sir J. J. Thomson had declared that he could not understand the complexity of spectral phenomena on the basis of the inverse square law. Sir Ernest Rutherford upheld that law as of fundamental importance in the beginning of his discourse, though he subsequently qualified that statement. He did not refer to Sir J. J. Thomson in this connection, we should point out, and we do not know in how far the two statements are incompatible with one another. The ordinary being, who had during recent years become reconciled with the doctrine that the old law of inverse squares is only an approximation, may accept its re-affirmation as placidly as he agrees to the deformation of the atom and its nucleus. In fact, the student of the older days may rather wonder why he had not before been told about deformed atoms, and how the atoms have so long managed to impress their "normal" respectability on physicists and chemists. We do not overlook that the deformations are no more supposed to take place under ordinary conditions, than the chemist fancies that Nature works with the high pressures and temperatures and strong reagents of the physiological laboratory. But we imagine that our readers would welcome a discourse on the means by which the electrons find their way back into the battered atoms and the atoms regain their character.

APPLICATIONS OF THE WILLIAMS-JANNEY VARIABLE-SPEED GEAR.

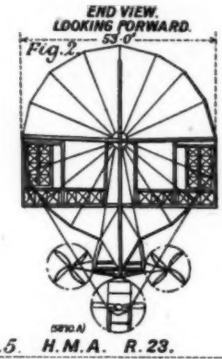
(*Concluded from page* 694.)

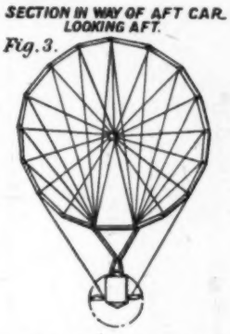
IN this, the concluding article of this series, we propose to deal with some examples of the application of the Williams-Janney gear to traction purposes and to refer briefly to some other of the miscellaneous ways in which it has been employed. We may first direct attention to Figs. 25 to 27, on page 795, which show a 3-ton Wolseley standard chassis adapted to take the "Williams-Janney" gear drive. The transmission gear consists of a variable-speed gear pump end coupled direct to the engine shaft and connected by piping to two variable-speed gear motor ends, which independently drive the rear wheels by means of chains, thus acting as a differential. By the use of two motor ends of the same capacity as the pump end a permanent reduction of two to one is obtained between the engine shaft and the sprocket pinion shafts. The control of speed both ahead and on the

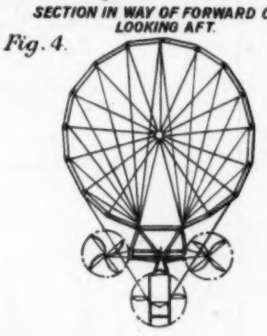
BRITISH NAVAL AIRSHIPS AND MAST MOORING GEAR.

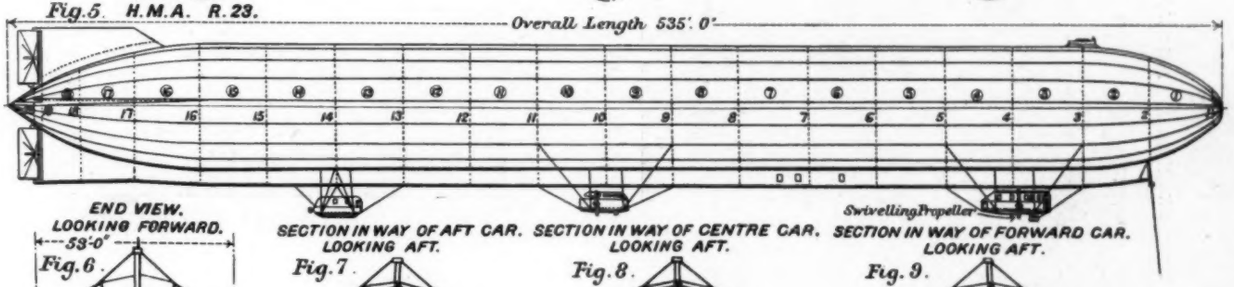
CONSTRUCTED BY MESSRS. VICKERS LTD., ENGINEERS, BARROW-IN-FURNESS.

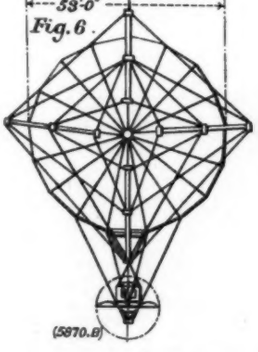
(*For Description, see Page 759.*)

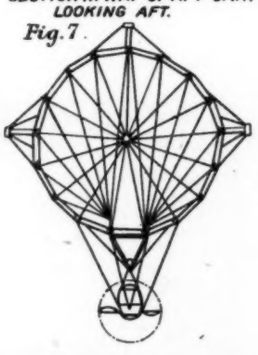


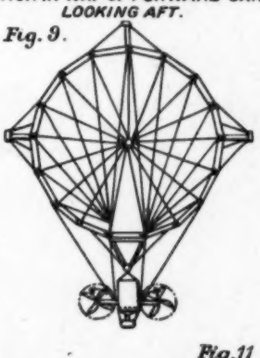


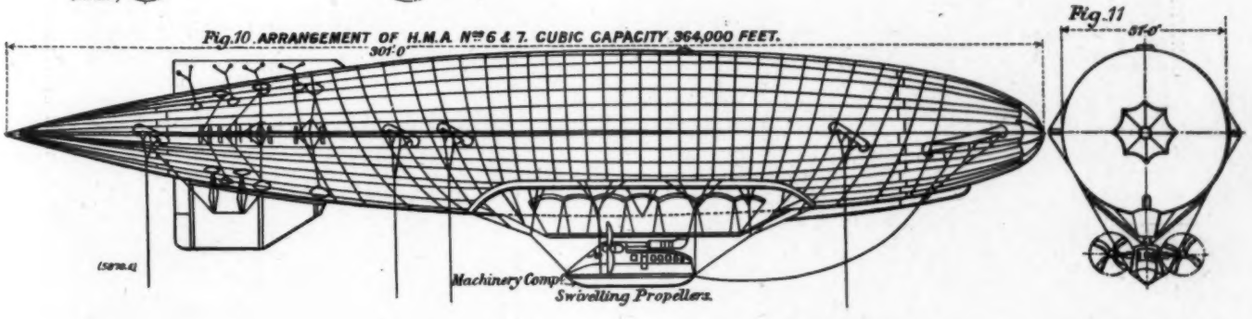


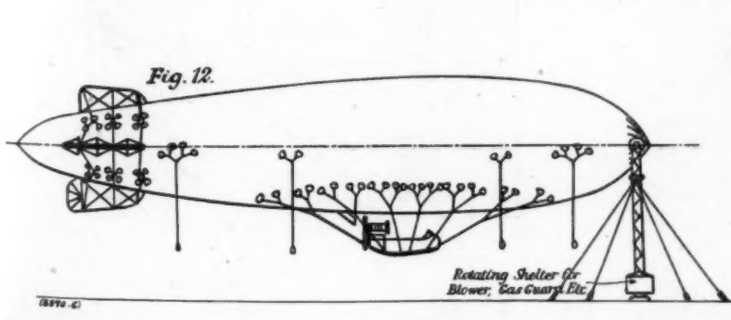


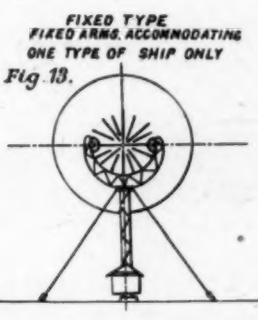












(*To face page 756.*)

H.M. AIRSHIP R. 9.

CONSTRUCTED BY MESSRS. VICKERS LTD., ENGINEERS, BARROW-IN-FURNESS.

(*For Description see Page 757.*)

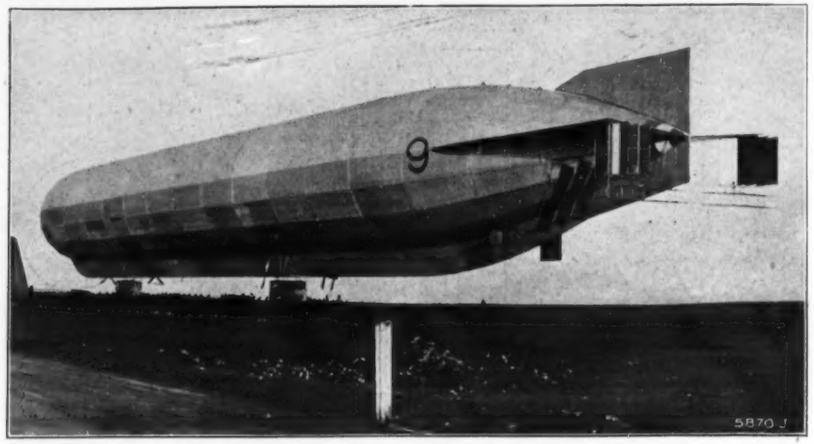


FIG. 15. AIRSHIP PREPARING TO ASCEND.

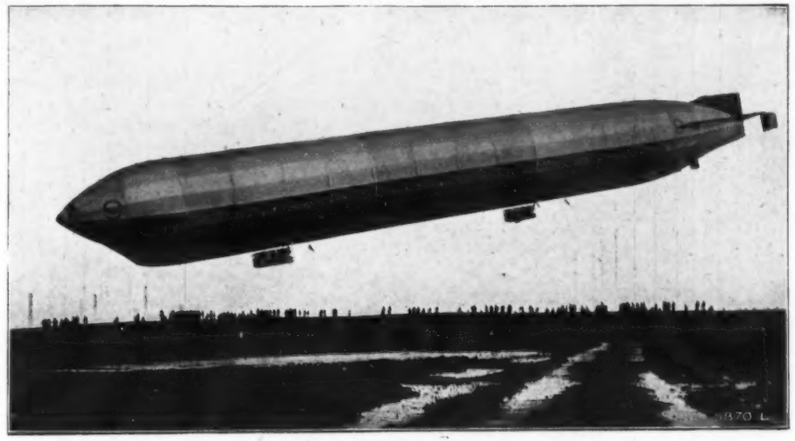


FIG. 16. AIRSHIP DESCENDING AFTER A FLIGHT.

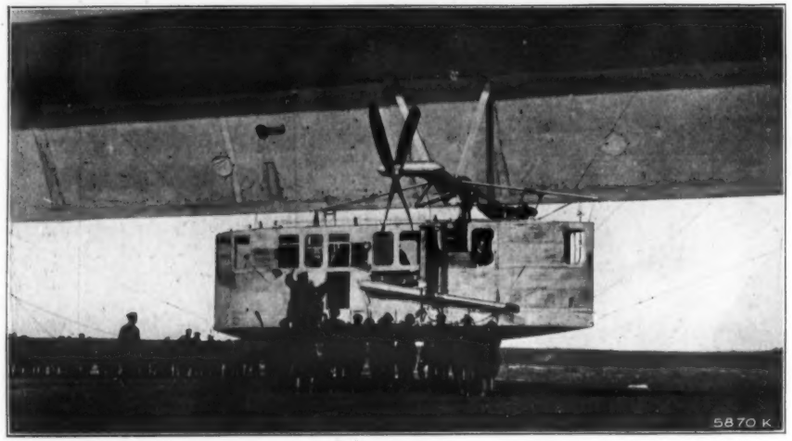


FIG. 17. FORWARD CAR SHOWING SWIVELLING PROPELLERS.

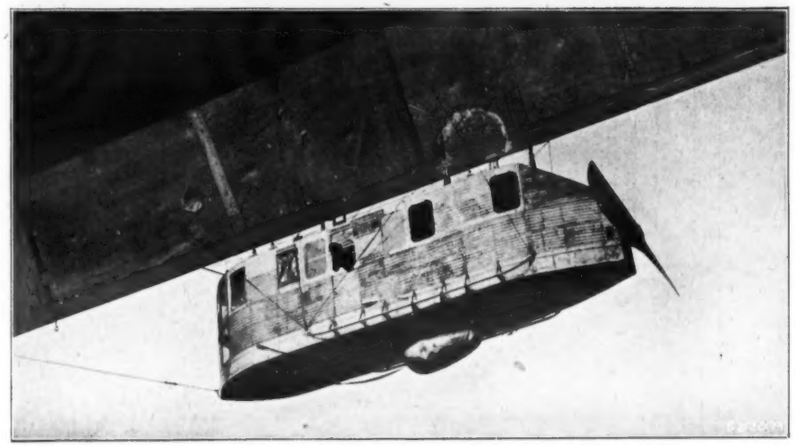


FIG. 18. REAR CAR WITH GERMAN MACHINERY INSTALLED.

H.M. AIRSHIP R. 23.

CONSTRUCTED BY MESSRS. VICKERS LTD., ENGINEERS, BARROW-IN-FURNESS.

(*For Description, see Page 757.*)

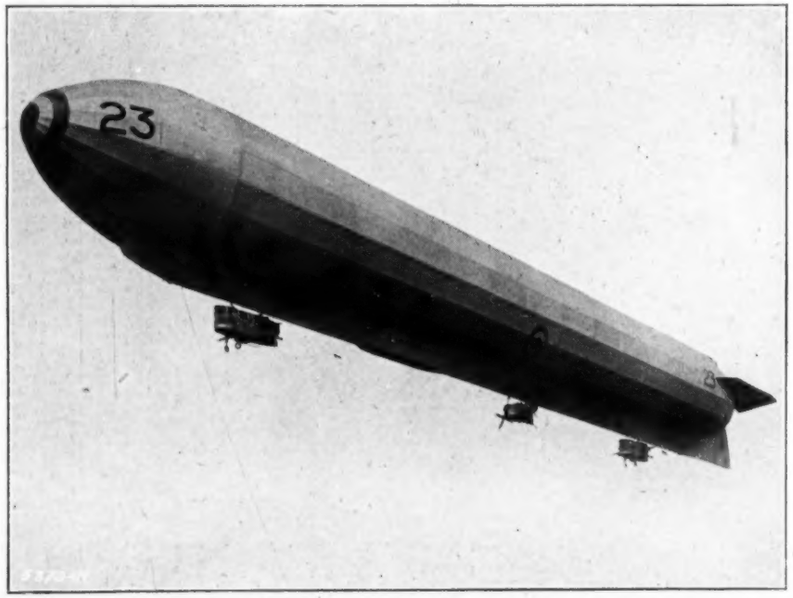


FIG. 19. AIRSHIP READY TO START FLIGHT.

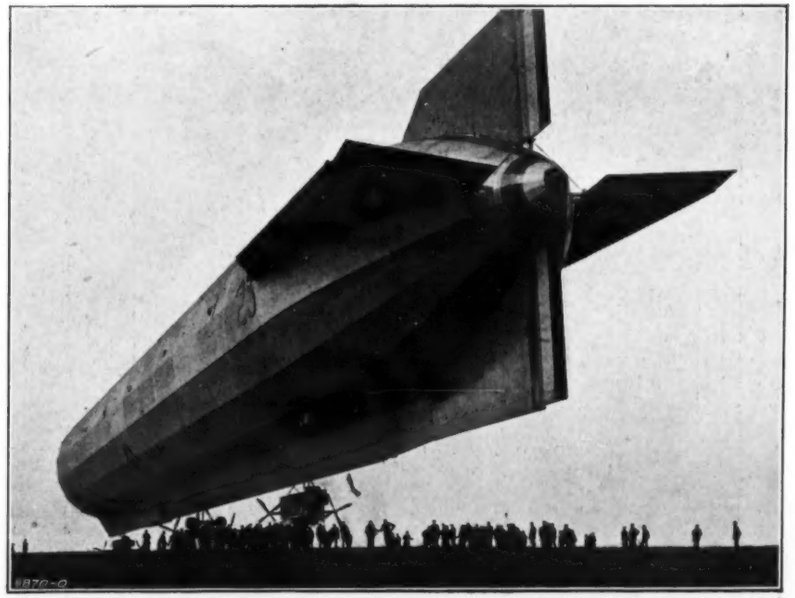


FIG. 20. AIRSHIP PREPARING TO ASCEND.

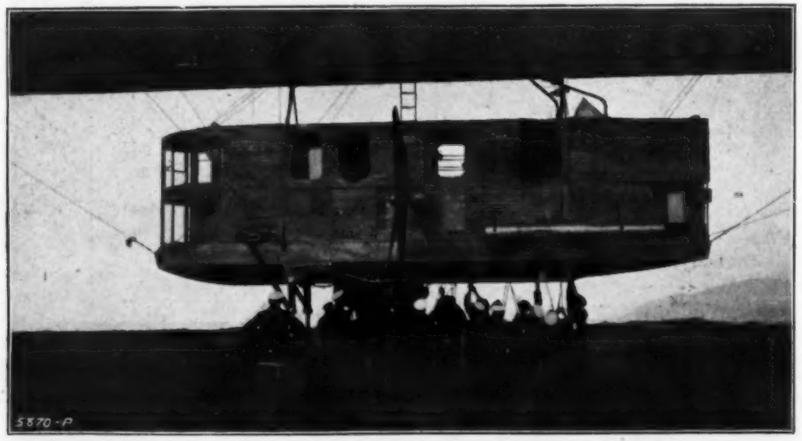


FIG. 21. FORWARD CAR SHOWING SWIVELLING PROPELLERS.

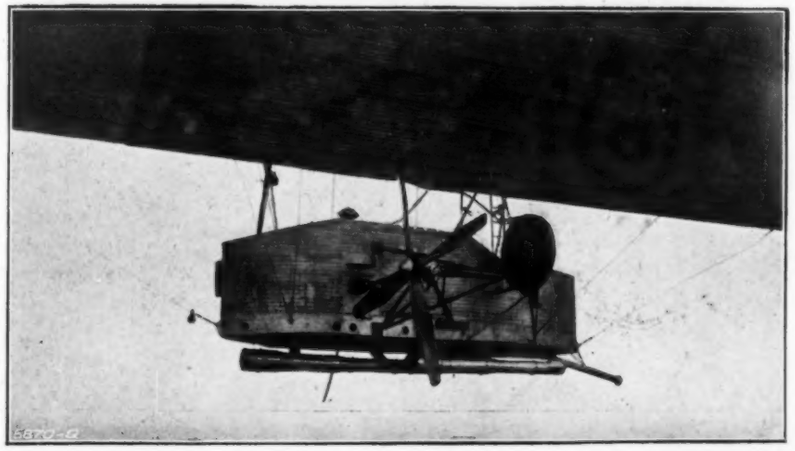


FIG. 22. CENTRAL CAR WITH FIXED PROPELLERS CARRIED ON OUTRIGGERS.

H.M. AIRSHIP R. 9.

CONSTRUCTED BY MESSRS. VICKERS LTD., ENGINEERS, BARROW-IN-FURNESS.

(*For Description see Page 757.*)

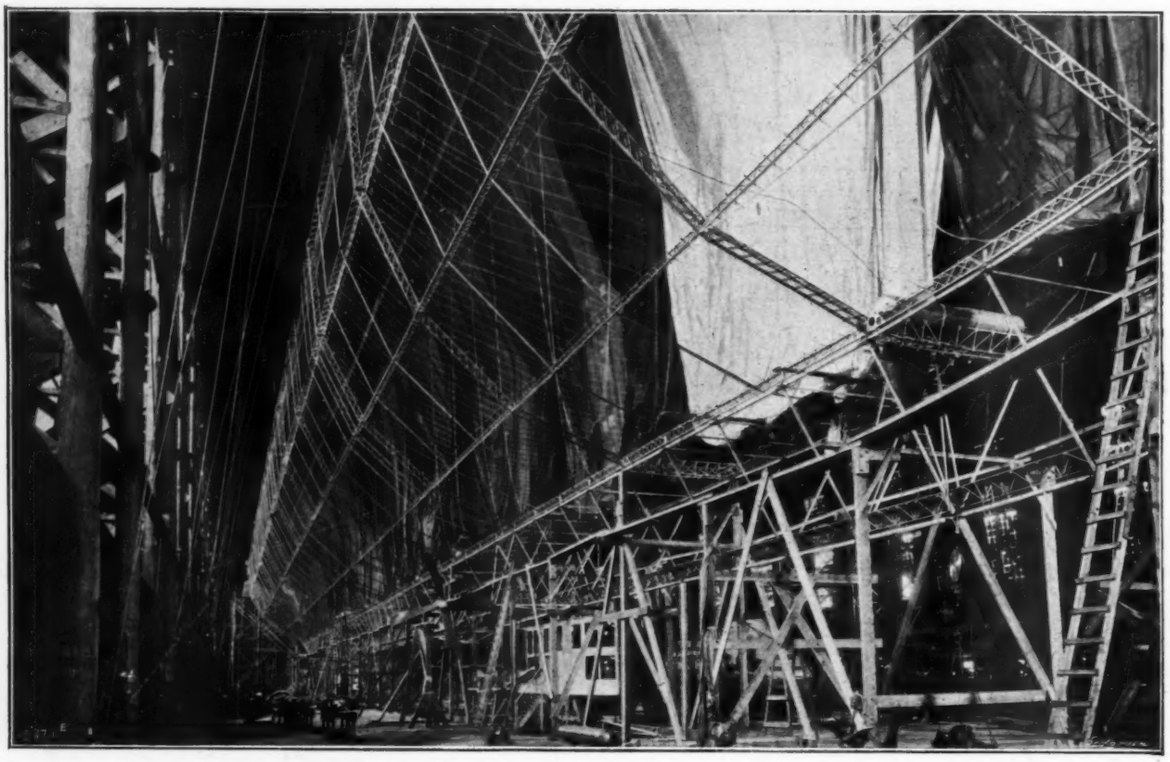


FIG. 23. AIRSHIP APPROACHING COMPLETION WITH GAS BAGS BEING INFLATED.

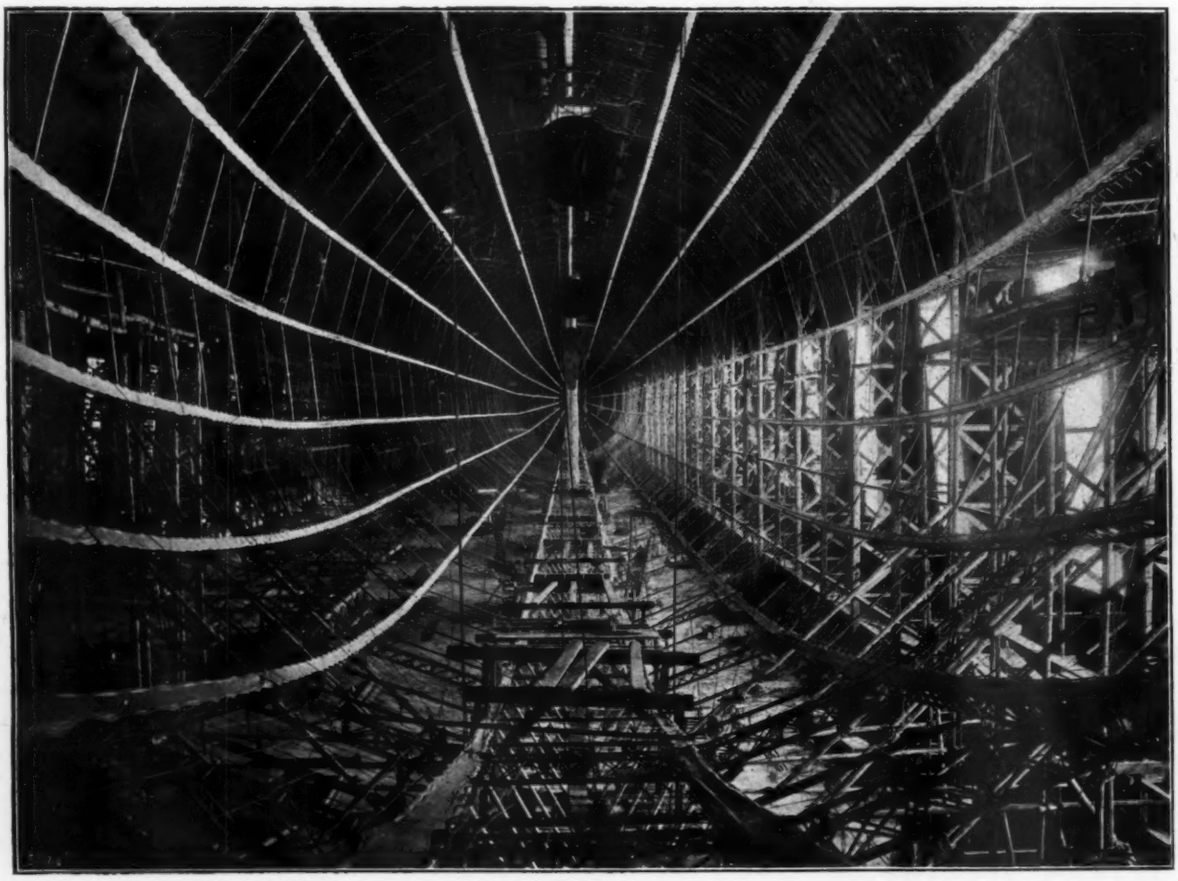


FIG. 24. VIEW OF HULL FRAMEWORK FROM INTERIOR.

(*To face page 757.*)

H.M. AIRSHIP R. 80 DURING CONSTRUCTION.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, BARROW-IN-FURNESS.

(*For Description, see Page* 797.)

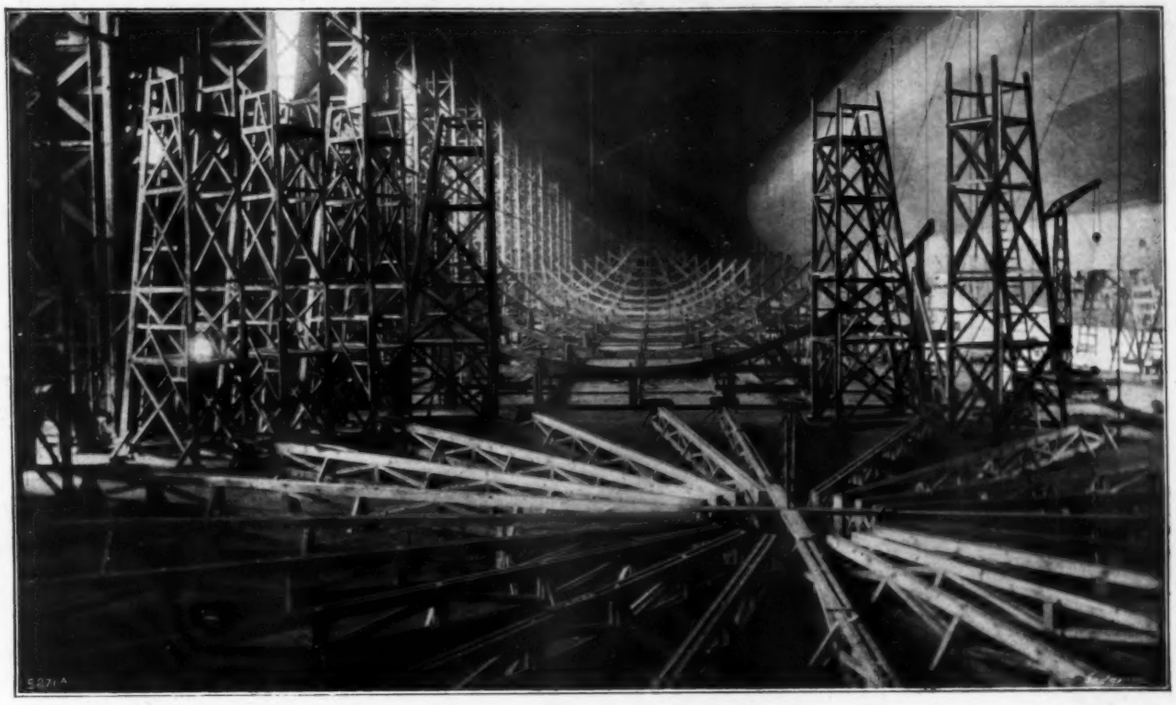


FIG. 35. RADIAL JIG AND ERECTION CRADLES.

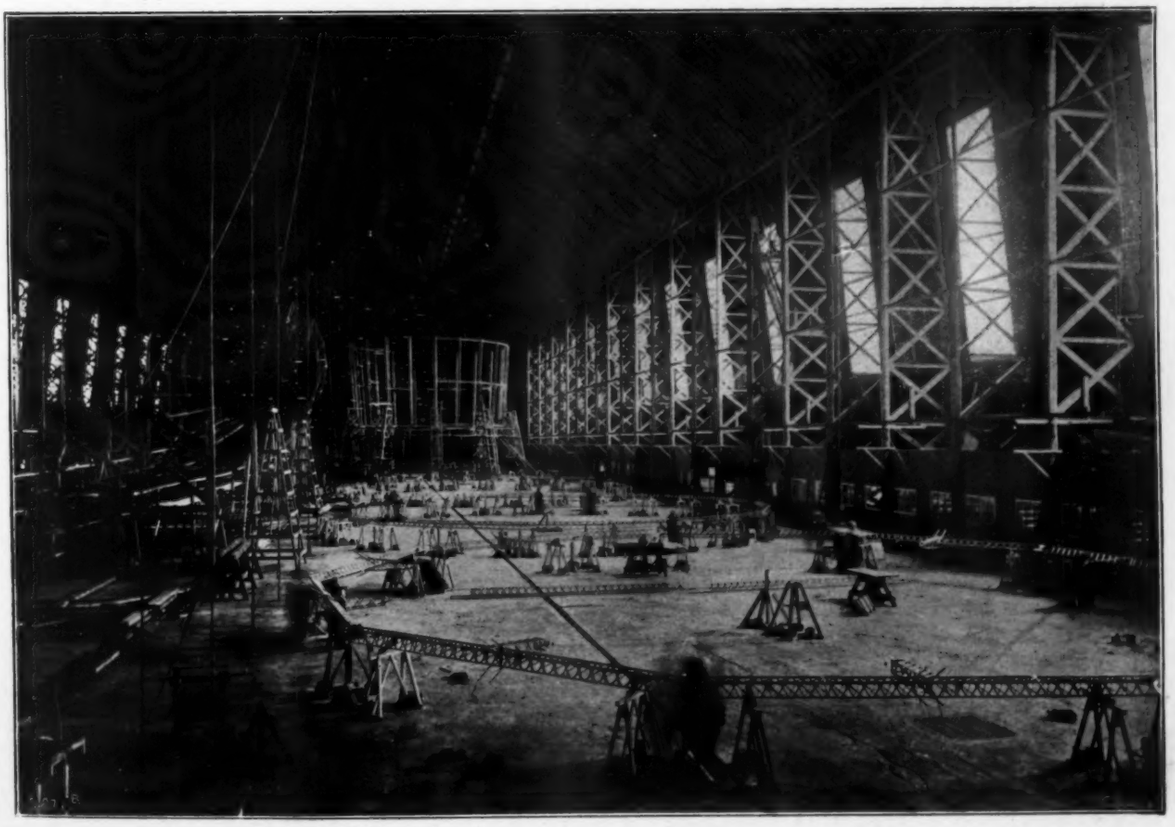


FIG. 36. ASSEMBLED FRAMES PLACED ON TRESTLES FOR RIVETING.

(*To face page* 798.)

H.M. AIRSHIP R. 80 DURING CONSTRUCTION.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, BARROW-IN-FURNESS.

(*For Description, see Page* 797.)

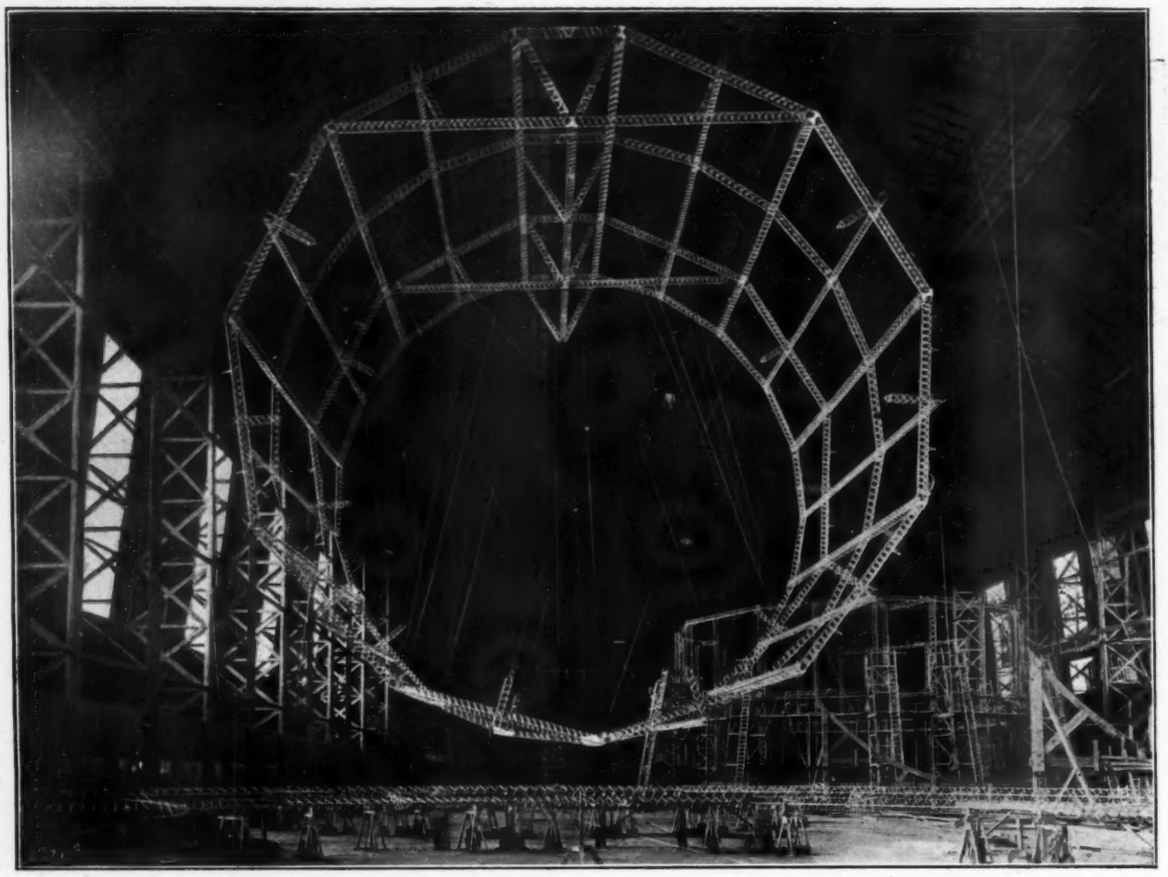


FIG. 37. FRAME UNIT LIFTED FOR TRANSFERENCE TO ERECTION CRADLE.

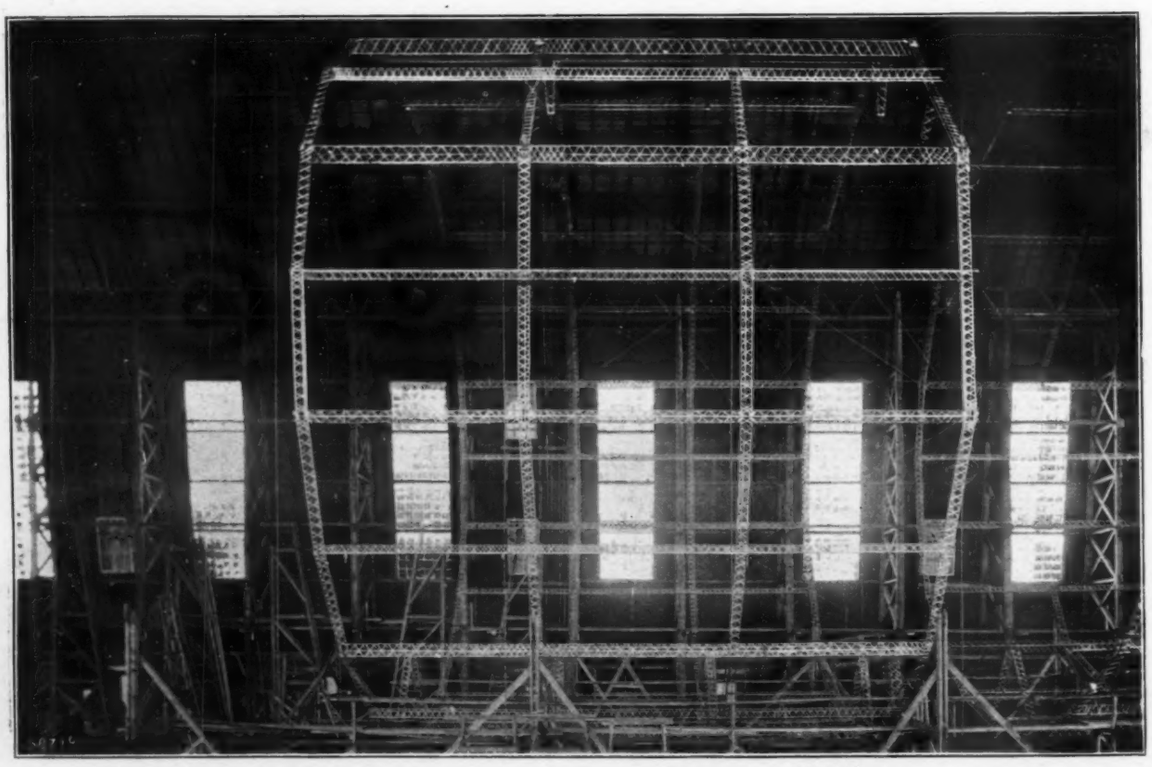


FIG. 38. FRAME UNIT IN POSITION ON ERECTION CRADLE.

SPECIAL TOOLS FOR AIRSHIP CONSTRUCTION.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, BARROW-IN-FURNESS.

(*For Description, see Page 797.*)

FIG. 39.

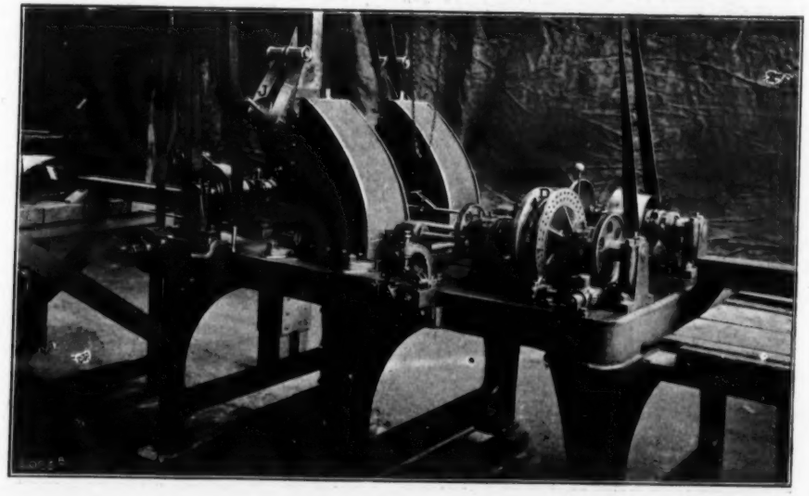


FIG. 40.

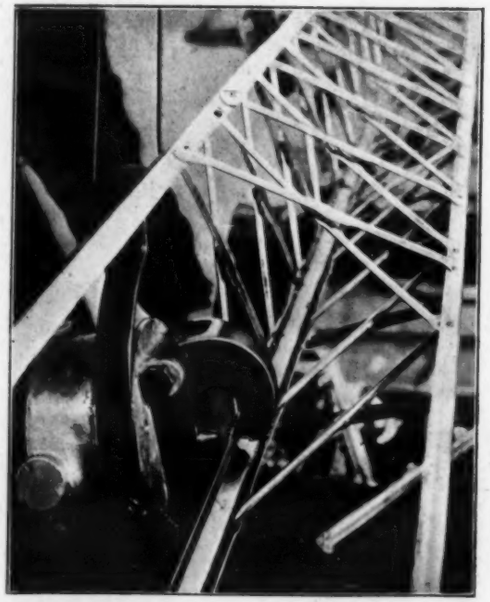


FIG. 41.

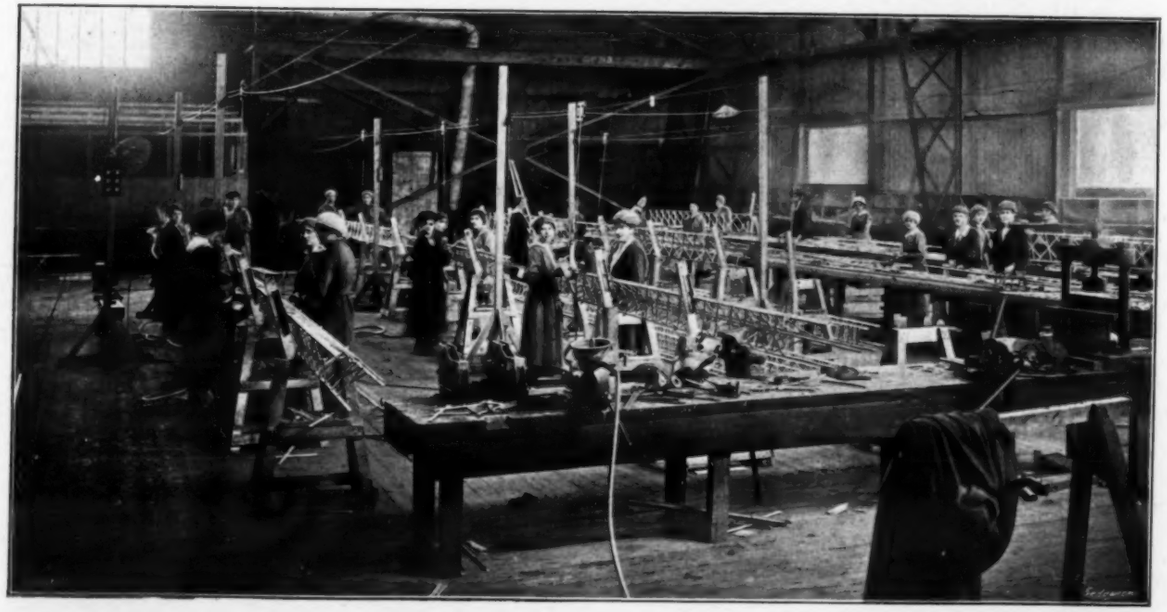


FIG. 42.

LATHE FOR CUTTING SCREW-THREADS ON GAUGES.

CONSTRUCTED BY MESSRS. DRUMMOND BROTHERS, LIMITED, ENGINEERS, GUILDFORD.

(*For Description, see Page* 799.)

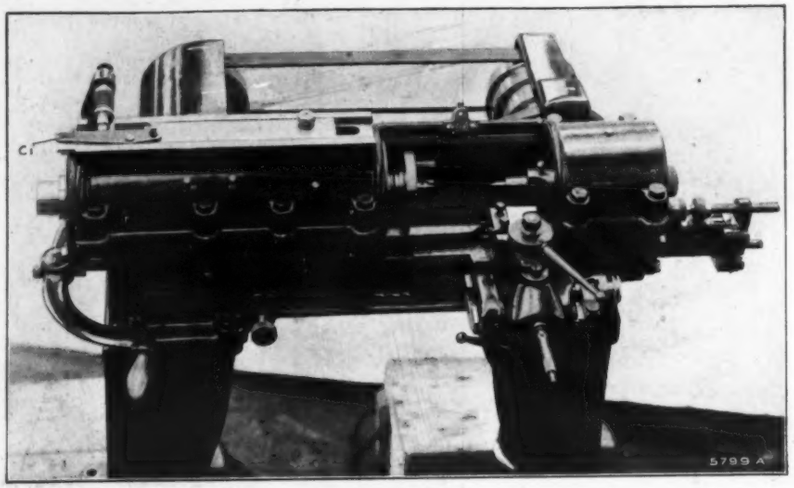


FIG. 1.

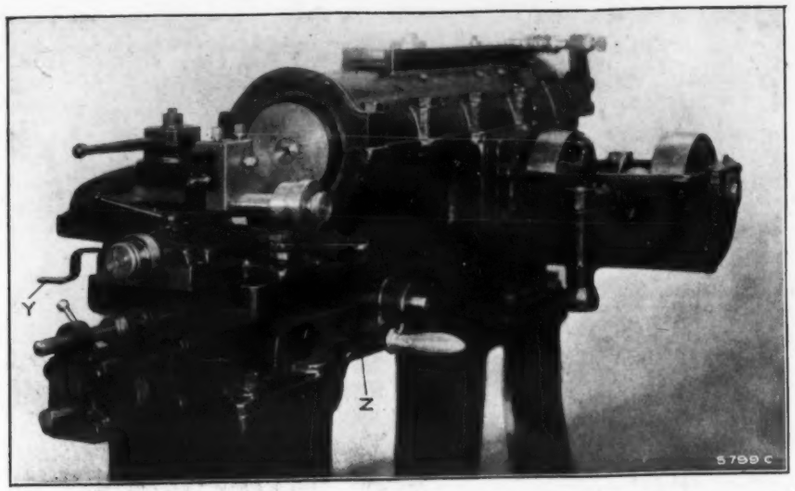


FIG. 3.

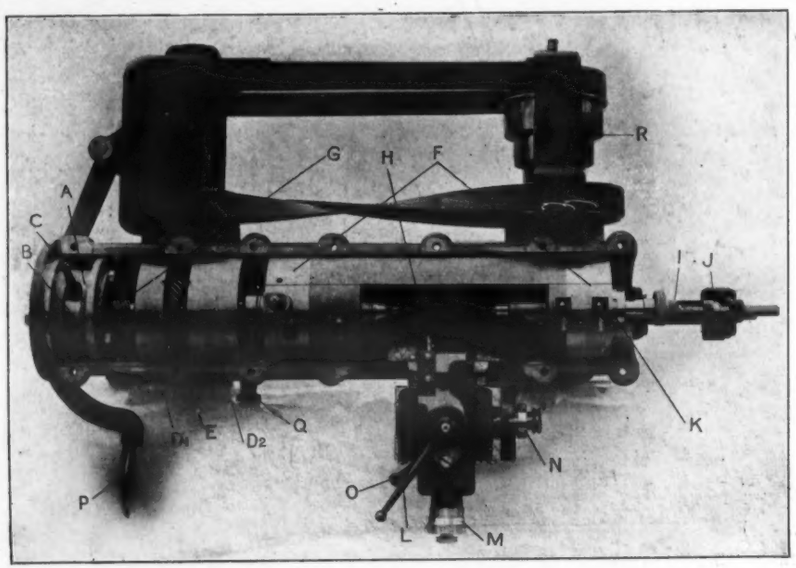


FIG. 2.

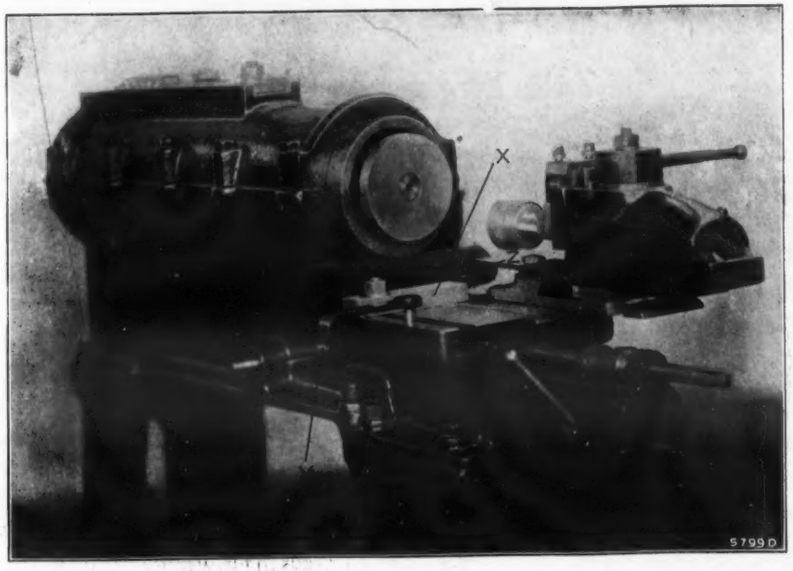
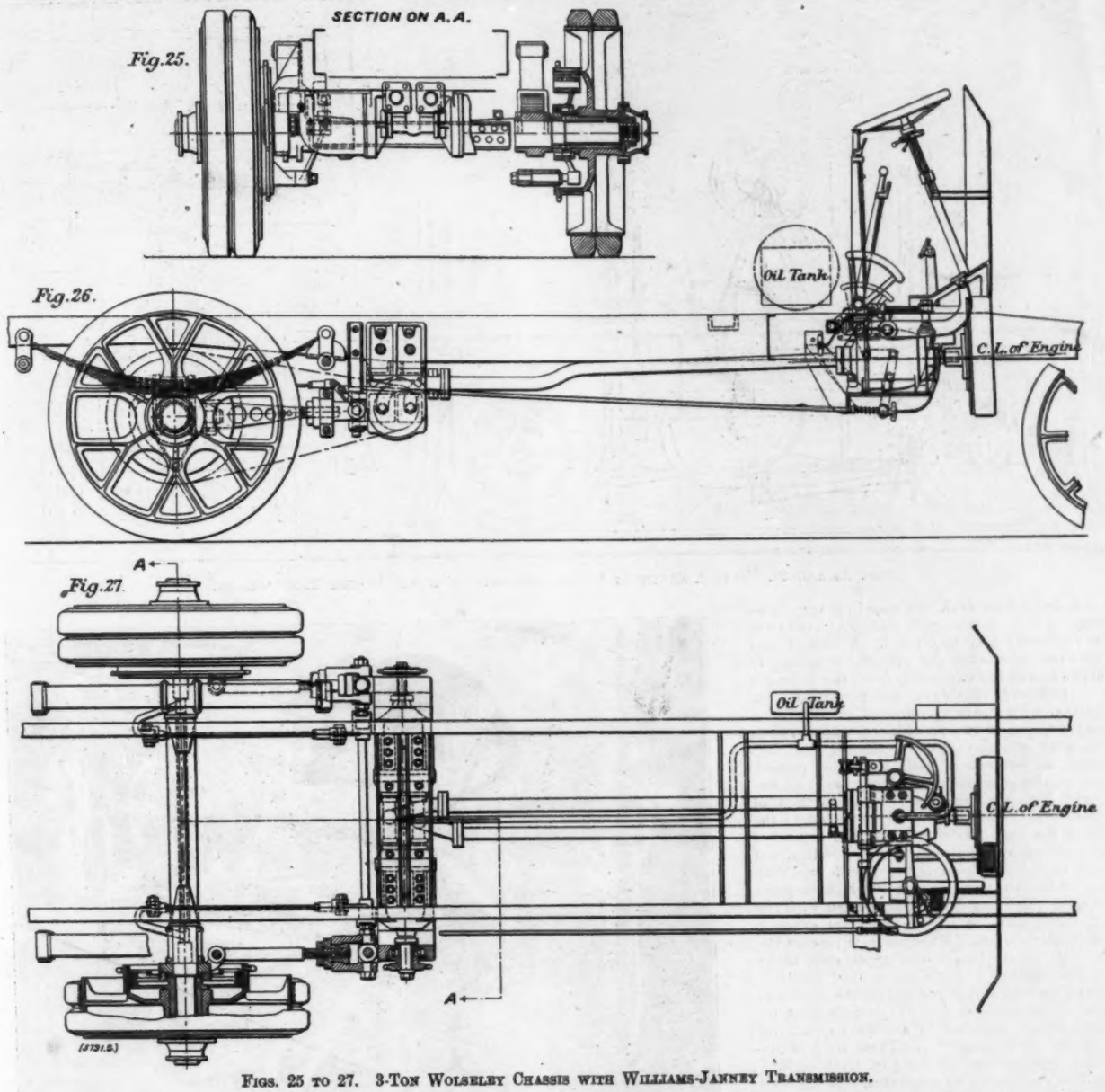


FIG. 4.

(*To face page* 799.)

APPLICATIONS OF THE WILLIAMS-JANNEY VARIABLE SPEED GEAR.



FIGS. 25 TO 27. 3-TON WOLSELEY CHASSIS WITH WILLIAMS-JANNEY TRANSMISSION.

reverse is effected by a single lever which operates, through a quadrant and pinion, the control shaft of the variable-speed gear motor end. A bye-pass valve connecting the pressure and return pipes, and operated by a pedal, is fitted for use when coasting. The chassis shown in the illustrations has been running continuously on the ordinary works' service for the last three years without requiring any repairs to the transmission gear. As a matter of fact the gear on being opened up after two years' service was found to be even in rather better condition than when first installed.

Experience has proved that the use of this form of transmission affords the following advantages: The infinitely variable speed range coupled with the high starting torque obtainable enables the vehicle to be started smoothly on the steepest gradients. With a fully-loaded lorry starting and stopping tests were carried out on a gradient of 1 in 4, with most satisfactory results. The elimination of the gear-box and the use of a single lever for controlling the speed over the whole range renders the vehicle extremely easy to handle, the driving of this lorry having been done most of the time by a woman. The absence of all shocks and jerks, especially at starting, together with the elimination of racing of the engine, reduces the wear and tear of the chain, tyres and engine, and thereby lengthens their lives. The usual brakes can be dispensed with and the braking effort effected by the variable-speed gear itself. The maximum speed of the vehicle consistent with road conditions and power of engine is always obtained, thereby giving a greater average rate of travel, whilst the running of the engine always at its most economical speed results in greater economy in the use of fuel and better carburettor regulation. There is no stalling of the engine under any circumstances and the maximum pull is always available at any speed from the slowest creep to full speed, regardless of engine capacity, with entire absence of peak load on the engine itself, the latter being virtually as flexible as a steam engine, but more positive.

An application of the gear to a 12-ton rail motor coach may be mentioned. The petrol engine driving this coach is of 75 brake horse-power connected through double helical gearing to a variable-speed gear pump end running at 500 r.p.m. The pump end is connected by piping to a motor, end and the drive from this to the back axle is by means of a silent chain running in a dust-proof case. The vehicle is designed for a maximum speed of 40 m.p.h., with a starting torque on the back axle of 14,500 in.-lb. and a normal running torque of 7,250 in.-lb. The transmission gear is controlled from either end of the car by means of a hand wheel which operates the control shaft of the pump end through shafting and mitre gears. The oil reservoir for the variable speed gear is placed in a convenient position near the driver.

Figs. 28 and 29, on page 796, show a shunting locomotive adapted to take a "Williams-Janney" variable-speed gear transmission. The petrol engine of 25 h.p., drives through a worm-reduction gear, the pump end (marked A end in Fig. 29), of the variable-speed gear, the motor end (marked B end in Fig. 29) of which is connected to a chain sprocket shaft by means of a spur reduction gear, the final drive on to the axle of the locomotive being by means of a roller chain. The control of the machine is effected by means of a hand wheel in the cab. This loco-

(To face page 796.)

APPLICATIONS OF THE WILLIAMS-JANNEY VARIABLE SPEED GEAR.

Fig. 28.

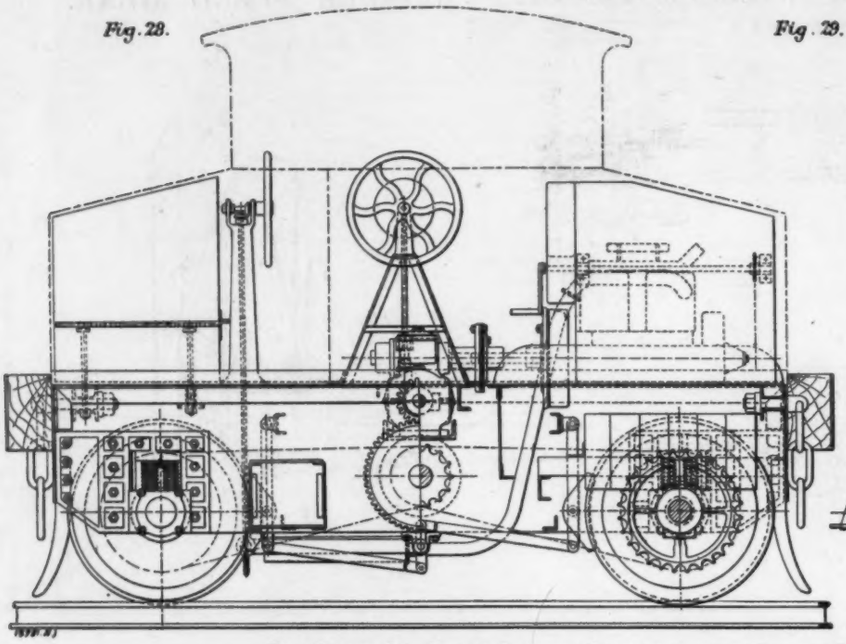
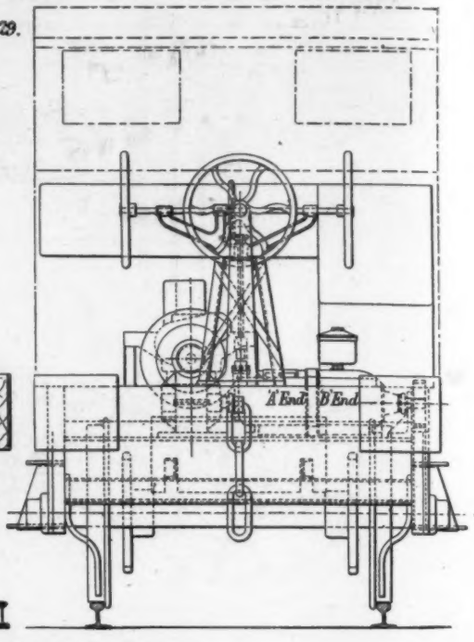


Fig. 29.



FIGS. 28 AND 29. PETROL SHUNTING LOCOMOTIVE WITH WILLIAMS-JANNEY TRANSMISSION.

motive handles yard work and shunting very satisfactorily up to 10 m.p.h., with loads up to 100 tons, and is extremely easy to control. A load of over 200 tons can be started and run on the level. It has given complete satisfaction from the points of view of economy, reliability and performance in competition with steam locomotives.

Turning to one or two miscellaneous applications of this gear, we may mention that it has been employed in connection with hydraulic presses, the use of the gear dispensing with the accumulator and high-pressure pipes. The method of operation is as follows: A lever connected to the control of the variable delivery pump is depressed by the operator and the ram rises. A vertical rod attached to the crosshead is fitted with two stop collars. When the ram reaches the highest point of its travel, the lower stop collar engages with the control valve and the oil in the press cylinder becomes under suction. When the ram reaches the lowest point of its travel, the upper stop collar returns the control lever to the neutral position. Practically no load is required to operate the lever. The gear has also been applied to hydraulic riveters, the control being operated by a pedal so that the operator has both hands free. These riveters are being used very successfully for ¾-in. rivet work.

As a final example of an employment of the gear we may refer to Fig. 30, annexed, which shows its application for starting aeroplane engines on test. A variable-speed gear coupled direct to a small electric motor is mounted on a trolley. The trolley is wheeled up to the engine and the variable-speed gear motor end shaft clutched to the engine shaft. The motor is then started up and the speed of the motor end shaft increased until the engine starts, when the clutch disengages and the trolley can be wheeled away to the next engine. The entire operation takes about 2 minutes, and the apparatus has been found very valuable by the works where it has been adopted. It can also be used for "running in" a new engine without petrol at slow speeds.

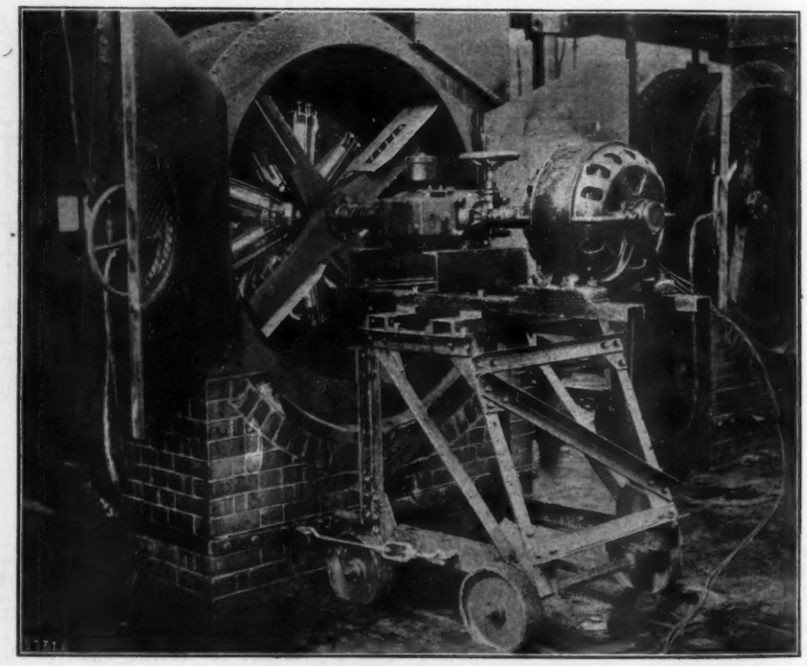


FIG. 30. ELECTRO-HYDRAULIC AEROPLANE ENGINE STARTER.

THE HUMANISATION OF INDUSTRY.

PERHAPS the most striking industrial feature of recent times, certainly one which war manufacture has brought into notice and which is likely to be left as a permanent benefit from its conditions, is the amelioration of toil by the provision of those elementary comforts which in themselves do so much to make labour tolerable. During the period when production without stint, and irrespective of cost, was a national necessity, the authorities who were all-powerful to effect any change considered expedient, made two discoveries of no small moment. The first was that production did not depend upon the hours worked. The subject of fatigue and the best period of labour in terms of output received detailed and scientific analysis. The consideration first resulted in the restoration of a weekly day of rest, and the minimising, so far as possible, of the transgression known as overtime. The normal working day did not come into being without trouble; any shortening of hours has always been viewed dubiously by employers. But that hours in many instances were too long was proved by increased production due to instituting a shorter working day. Obviously such a policy has limits, and there is a point when shorter time must result in lessened output. The best spell of labour in terms of production is a clear gain to both master and man.

The second discovery which has led to large capital expenditure, fully justified by the results, was the excellent effect obtained by the provision of ample well-cooked food at a minimum price. Canteen management is becoming an art of no mean order, and the improvement which to-day exists, by

comparison with a few short years ago, is very striking.

To put the matter shortly, it is conceded by all concerned that adequate rest and proper food are factors wholly in favour of increased production. In combination with modern methods of sectionalisation, standardisation, repetition and interchangeability, these more human considerations went hand in hand. In the words of the present Premier, it took the greatest war on record to humanise industry. Underlying industrial unrest is the objection, voiced on the first day of the National Conference, that labour objects to be a marketable commodity and requires its humanity recognised.

There is a wider viewpoint to the question, and to obtain unbiased evidence and first-hand consideration Matthew Arnold may be cited. This eminent author was an educational authority, in addition to which he had two main prejudices; these were his contempt for Puritanism and his criticism of the middle classes. Yet for all this, two essays, "Democracy" and "Equality," will bear perusal in connection with the present industrial situation. He defines "civilisation as the humanisation of man in society." Man is civilised when the whole body of society comes to live a life worthy to be called human, and corresponding to man's true aspirations and powers.

He criticises at length the blindness of the governing classes to the aspirations of the mass, "Themselves a power reposing on all which is most solid, material and visible, they are slow to attach any great importance to influences impalpable, spiritual, viewless." "Democracy is a force in which the concert of a great number of men makes up for the weakness of each man taken by himself." "Nations are not truly great solely because the individuals composing them are numerous, free and active; but they are great when these numbers, this freedom, and this activity are employed in the service of an ideal higher than that of an ordinary man, taken by himself." "Perfection will never be reached; but to recognise a period of transformation when it comes, and to adapt themselves honestly and rationally to its laws, is perhaps the nearest approach to perfection of which men and nations are capable."

Matthew Arnold will not be judged a raw extremist; he was a man of great scholarship and high attainments, Greek in spirit, loving beauty, a critic of no mean order, and these two essays should be re-read in this time of national crisis. His plea is for humanisation of society, and by very slight alteration the phrases quoted can be made applicable to the industrial revolution now in being, and to the disquiet which heralds its renaissance. The present unrest is impalpable, spiritual and viewless in many particulars. Industry has to learn that it is a co-operation wherein the concert of a great number of men makes up for individual weakness. Industry reached its highest plane when the ideal sought by its efforts was the national interest.

Recognition of the period of change summoned the National Conference to find a *modus vivendi* and a means of adjustment. The humanisation of industry having been started, it cannot abruptly be ended, the concessions of war-time to minimise fatigue and minister to physical wants are not temporary measures to be discarded upon commercial resumption. It is well to recognise the period of transformation and all that it involves.

Perhaps another quotation will be suffered. Dealing with the desire for even more freedom and emancipation, Arnold says: "So potent is the charm of life and expansion upon the living; the moment men are aware of them, they begin to desire them, and the more they have of them, the more they crave." This, then, is the bed-rock upon which present claims to fuller expansion rest. It would be sheer folly and obscurantism to deny that times are changed and the worker has a legitimate claim to fuller opportunity. As to how much of this can be granted is a matter for the conference to solve; too much will strangle the enterprise upon which industry rests, too little will retain present insecurity. One thing is certain, that, save for the wild extremist, labour understands it is impossible to obtain all that may be in sight, but as prosperity increases and wealth production multiplies it will not for the future remain quiescent. This is an outstanding fact it were commonsense to face squarely.

A new era cannot come without sign and portent: it is well to adjust ourselves to the realisation when it comes. It is a common humanity in which we all associate, frank recognition of this fact will save disappointment and reaction of an unpleasant character.

THE EVOLUTION OF THE BRITISH NAVAL AIRSHIP.

(*Concluded from page* 759.)

IN our previous article on this subject we dealt, on page 758 *ante*, with the circumstances which led up to the design of the R.80. We now propose to give some particulars of the construction of this ship, which we illustrate by drawings reproduced in Figs. 30 to 33 on page 798, and by half-tone engravings, Fig. 34 on page 798, and Figs. 35 to 38 on Plates LX and LXI. The overall length of R.80 is 530 ft., its diameter 70 ft., its height 85 ft., and its gas capacity 1,250,000 cub. ft. Two main modifications in the design of the hull, in comparison with those of the earlier ships, will be apparent from an inspection of the drawings. The most obvious is the shape of the hull, which has no parallel portion amidships, but is made of a perfect stream-line form throughout its length. The absence of the external keel girder will be noted, and an inspection of Fig. 37 will show that this has been placed inside the hull. These two features must considerably decrease the resistance of the hull, and so enable a higher speed to be obtained for a given power than would be the case with the earlier designs of hulls. Many minor improvements have been introduced in the design of the girders and joints, and also in the system of wiring, but we cannot spare the space necessary to deal with these in detail. The hull is also provided with two gun positions, one on top near the nose and another at the extreme after end. These have been specially designed for carrying guns of heavy calibre. The firm's patent bow mooring attachments, referred to in our previous article, are also fitted, and these enable the ship to be moored in the open to a mast, or tower, in such a manner that it is free to turn in any direction so as always to face the wind. Special attention has been given to the design of the control gear for steering the ship, and also to the gear for operating the gas valves, &c. All the connections from the car to the hull are placed in a shaft, which, whlie protecting them from the weather, leaves them perfectly accessible for inspection or adjustment during flight. Four cars are carried, but, of these, the forward control car and machinery car are flexibly connected together to form a single stream-line body. The two rear cars, which contain machinery only, are attached to the hull amidships, and are placed one on each side of the ship, as shown in Figs. 31 and 33. The control car contains the whole of the navigating controls and instruments, as well as the wireless apparatus, and is sufficiently large for the comfort and convenience of the crew. The machinery car, immediately behind the control car, carries two 240-h.p. Wolseley-Maybach engines arranged *en echelon*, and both are coupled to a single propeller situated at the rear end of the car. The driving arrangements are such that the propeller can be driven by either engine separately. The two rear cars each contain one 240-h.p. engine driving a propeller at the after end of the car without reduction gearing. Reverse gear is, however, fitted to these propeller drives, for use when the ship is landing. Buffer bags of a special type are fitted under each of the cars, and these bags, besides giving a useful cushioning effect when landing on the ground, also suffice to keep the ship afloat when alighting on the sea. We understand that arrangements are under consideration for flying the R.80 across the Atlantic during the summer, a trip which the vessel should be able to accomplish with ease.

By the courtesy of the builders we are able to reproduce on Plates LX and LXI, and on page 798, some interesting photographs illustrating the method of constructing and erecting the hull framework of this airship. In the foreground of Fig. 35, on Plate LX, will be seen a radial jig frame, constructed of timber, on which the girders forming the periphery of the transverse frames are assembled. Each arm of the jig is provided with a sliding saddle, which can be set at the correct radial distance from the centre to accommodate a frame of any diameter, and the various members of the frame are temporarily fastened down to the saddles while the joints are fitted together. Fig. 36 shows a number of transverse frames, which have been assembled on the adjustable jig frame, placed on trestles for riveting-up, and the same illustration shows at the end of the shed a section of the hull framework in course of erection. As will be seen the sections are built up in the vertical position by fitting the longitudinals to two transverse frames, lifting these, joining up to another transverse frame placed underneath, and so on until a section of four transverse frames has been completed. Fig. 34, on page 798, shows such a section completed ready for lifting. The completed sections are then slung from the roof, lifted up, turned into the normal horizontal position, and transferred to the circular segmental cradles seen in the background of Fig. 35, on Plate LX. The process of lifting and transferring a section is well illustrated in Figs. 37 and 38, on Plate LXI.

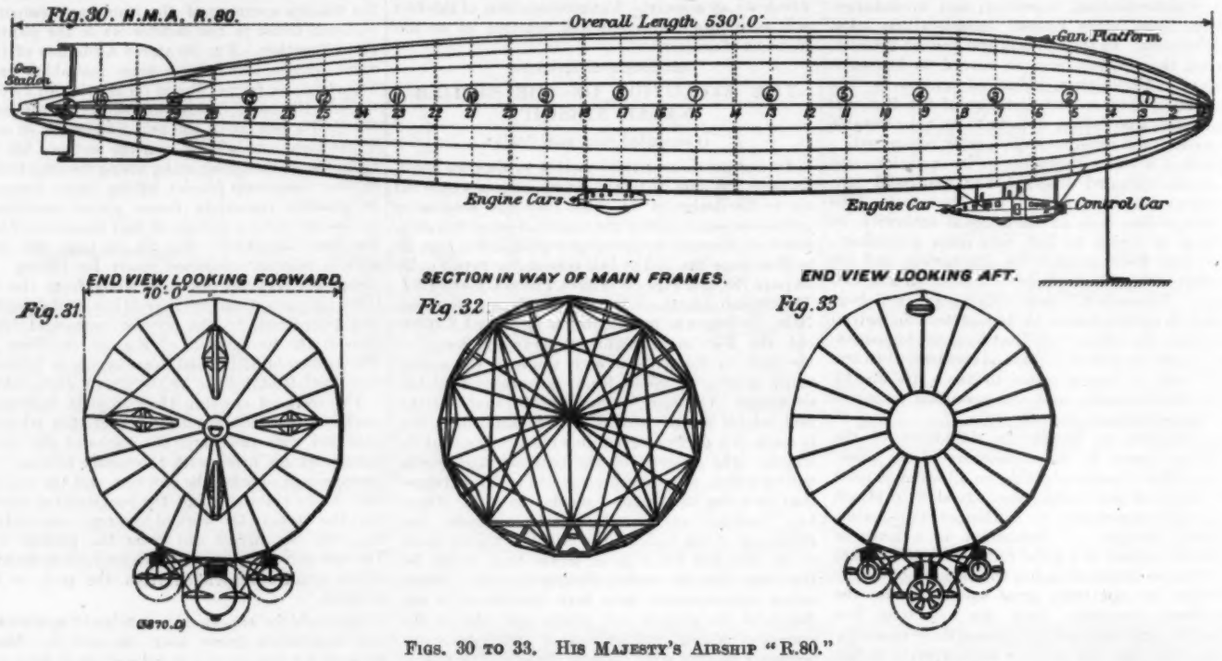
The work of erecting the complete hull framework is carried out on the circular cradles, which are provided with rails, and the joints of the airship framework are fitted with temporary rollers. This arrangement enables the sections, and the complete hull, to be rotated about the longitudinal axis, so that the whole of the work of joining up the sections, &c., can be carried out from the ground level. The necessity for men to work on high scaffolding, or on cradles suspended from the roof, is thus avoided.

As would be expected, a number of special tools and appliances have been devised by Messrs. Vickers for use in the construction of large rigid airships. These include salt baths for the heat-treatment of Duralumin, a special drilling machine for girder details, a pneumatic riveter, a tension-meter for adjusting the tension in the wiring of the hull framework, a spinning machine for straightening wires, and a number of press tools for stamping out the bracing pieces. Of these perhaps the most interesting is the drilling machine, which not only drills the rivet holes in the channel and angle members of the girders, but can be set to drill them automatically at any pitching required; the necessity for a large number of different drilling jigs is thus obviated. We illustrate this machine in Figs. 39 and 40, on Plate LXII. The girders and spars used in airship work generally consist of braced members of rectangular, or triangular, cross-section, the sides being formed of web plating, or light-pressed bracing pieces, while the booms consist of channels or angles of a great variety of shapes and sections. An example of a usual type of girder is illustrated in Fig. 41, which will be referred to later. The machine we are describing is designed to deal with any section from a parallel-sided channel to a 90 deg. angle, including all kinds of special sections such as sloping-sided channels with lipped edges. It will also take flat strips, such as are used for keel plates or continuous butt straps. As will be seen, the machine comprises two universal drilling heads J mounted on a table, together with the mechanism for controlling the various movements. Fig. 39 shows the machine with a special form of channel section, lettered C, in position. The channel, in being fed through the machine in the direction of the arrow A, passes between a plain pressure roller and a toothed feed roll, which is driven, indirectly, by the pulley K, seen on the right-hand side in Fig. 39. The feed roll consists of a tool steel cylinder accurately ground to a definite diameter, and having a large number of inserted teeth of spring steel, which project only 0·02 in. from the surface of the cylinder. The load on the pressure roller is sufficient to cause the small teeth on the feed roll to sink into the metal of the channel until the edges of the latter come into contact with the cylindrical surface of the roll. This arrangement gives a pitch circle of constant diameter for the feed roll, with the result that the channel is fed forward with very great accuracy. In practice the limits of accuracy in feeding are of the order of

0·5 mm. in a length of 5 metres. The movement of the feed roll, and, consequently, the pitch of the holes drilled, is controlled by the pitch plates lettered D in Figs. 39 and 40, but most clearly shown on the right of Fig. 40. The mechanism is too complicated to explain in detail without the help of drawings, but the following brief description, with the aid of the half-tone illustrations, should suffice to give an idea of the method of operation. The pulley K drives the shaft on which it is mounted through a pair of friction plates, and this shaft drives the pitch plates through the medium of gearing and a horizontal shaft best shown in Fig. 40. Adjustable stops, which can be seen on the left-hand side of the pitch plates in the same illustration, are arranged to engage with mechanism which controls the rotation of the feed roll. The first stop starts the feed roll, which continues to rotate, feeding the channel forward until the second stop on the pitch plate engages with the mechanism, when the rotation of the feed roll ceases. By adjusting the positions of the two stops, the distance travelled by the channel can be varied as desired. Fine adjustment of this movement is effected by the right-hand plate in Fig. 40. This plate, which forms part of the outer casing of a differential gear, carries a pin which engages with a star wheel, and this star wheel can be made to rotate a worm and worm wheel (mounted on one of the differential shafts) in either direction. The small angular movement thus imparted to the worm wheel is added to, or subtracted from, the main motion of the feed roll. By this means pitch adjustment can be effected to within 0·001 in. It should be noted here that the holes drilled need not be uniformly spaced along the whole length of the channel. The feed arrangements are such that they can be drilled in groups with any spacing between the groups. The photograph from which Fig. 39 was reproduced shows two holes about 1 in. apart, followed by a space of about 1½ in., after which come two more holes 1 in. apart, followed by a space of about 6 in.; the holes, however, are too small to be visible in the reproduction. The longitudinal positions of the groups of holes on the two sides of the channel may also be different, but the general sequence must, of course, be the same on both sides.

The drills are fed into, and withdrawn from, the work, when the feed movement is completed, by mechanism driven by the pulley G, which is shown in both illustrations. As will be seen in Fig. 39, the pulley drives an adjustable-throw crank disc, and a connecting rod from this is attached to a lever on a rocking shaft under the table. This shaft is connected, by a system of shafts and gearing, to pinions gearing with racks on the drill heads, so that the latter are caused to reciprocate as the crank disc rotates. This mechanism is put into operation by a stop on one of the pitch plates, the stop engaging with a lever which moves a dog clutch. Part of this clutch is formed on the boss of the pulley G, which normally runs loose on its shaft, and the other part can slide on a feather on the shaft, so that when the two parts of the clutch are in engagement the shaft and crank disc are rotated. The movement of the drill heads can, if necessary, be effected by hand by means of the lever F, shown in Fig. 39, and the pitching mechanism can also be operated by the hand lever E if desired. The small triangular stop seen between the two drill heads in Fig. 40 is used, when a fresh channel is placed in the machine, to fix the distance from the end of the channel at which the first hole is drilled. The part lettered H in Fig. 39 is provided to stop the machine automatically when the drilling has been completed.

The machine, which can be tended by an unskilled female operator, is capable of dealing with from 200 ft. to 250 ft. run of channel section per hour, the rate naturally varying slightly according to the number of holes drilled. At this rate a complete set of channels and angles required for the



FIGS. 30 TO 33. HIS MAJESTY'S AIRSHIP "R.80."

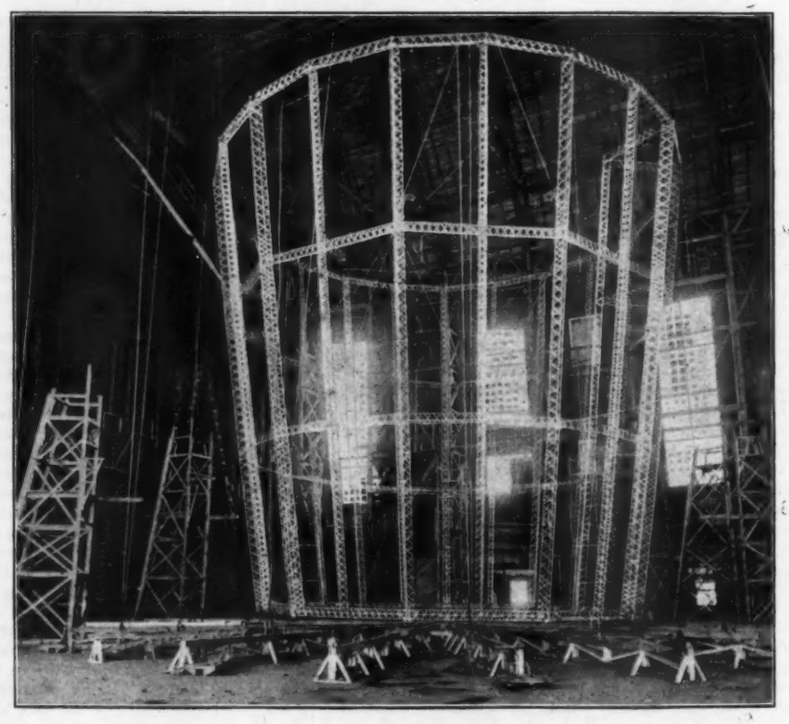


FIG. 34. COMPLETED SECTION OF HULL FRAMEWORK ON RADIAL JIG.

construction of an airship of the R.80 class can be drilled in 400 hours on one machine. It would thus be possible, in a case of extreme urgency, to complete this part of the work in about three weeks by working night and day shifts. An improved design of machine has, however, been designed recently, in which the rate of working, and the degree of accuracy, have both been considerably improved. This machine is provided with a hopper from which the undrilled channels are fed into the machine automatically, one after the other, the machine continuing to operate until the whole supply has been exhausted. Attachments are also provided on this machine to enable gaps, of any required length and position, to be left in a girder where special work, or complicated joints, occur, which necessitate drilling during erection.

The pneumatic riveter, above referred to, is illustrated in Fig. 41, on Plate LXII, where it is shown in operation on one of the girders for the R.80. As will be seen the tool is very simple in design, comprising an aluminium cylinder containing a piston, which is directly connected to the movable jaw, while the fixed jaw is carried by a hook-shaped steel forging bolted to the cylinder. Air, at about 80 lb. per square inch pressure, is supplied to the cylinder through a flexible tube coupled up to a short pipe, which forms a handle, and is fitted with a spring sleeve which operates the admission valve. Turning the sleeve admits air to the cylinder to close a rivet, and releasing the sleeve allows it to fly back to its original position, in which the air in the cylinder exhausts to the atmosphere. With air at the above-mentioned pressure, the closing pressure exerted on a rivet amounts to 1½ tons, and the consumption is rather less than 1 cub. ft. of free air per stroke. For work of a very delicate nature, an adjustable-pressure releasing valve can be fitted to limit the maximum closing force to any desired amount, so as to avoid the risk of damaging exceptionally fragile members of a girder. In open work, in a straight line, the machine is capable of closing rivets at the rate of about 15 to 20 per minute, but on intricate work, such as that on the girder illustrated in Fig. 41, the speed of operation is greatly reduced by the necessity for continually inserting and withdrawing the jaws. In such cases rivets can be closed at the rate of about 5 or 6 per minute, but, in practice, the output depends mainly upon the rate at which the rivets can be inserted into the holes. The machine is claimed to be exceptionally light and handy, and, as an illustration of this, it may be mentioned that all the rivets in the girder shown in Fig. 41, including those in the central palm of the bracing pieces, are readily accessible to the jaws without moving the girder. The working of these machines is greatly facilitated by the method of suspension adopted. The arrangement is best shown in Fig. 42, which is a general view of a portion of a girder building shop equipped with these machines. As will be seen each riveter is suspended from a small travelling carriage running on a horizontal wire rope carried by vertical posts. Another wire rope, fixed at one end, runs parallel with the supporting rope, and a loop of the former is taken round a pulley on the carriage, down to another pulley attached to the riveter, up again to the carriage, along horizontally to another post, and down over a pulley to a counterweight. This arrangement enables the riveter to be moved vertically or horizontally with the minimum effort on the part of the operator, and the semicircular suspension band clearly shown in Fig. 41 permits the tool to be rotated freely in any plane. About 15 of these machines can be economically employed in the manufacture of the hull framework, and other structural components, of a single airship.

From what we have said above, it will be evident that a very high degree of technical skill is requisite to deal with the problems involved in the design and construction of a successful rigid airship. A very little further consideration will also make it clear that technical problems are not the only ones to be solved in airship manufacture. The great multiplicity of parts and manufacturing operations necessary, call for great ability in the matter of works organisation, coupled with exceptional facilities for production. If further evidence of this is required we need only mention that the number of different parts in a rigid airship of the latest type is approximately 21,000, and the actual number of individual pieces amounts to about 1,600,000. The length of angle and channel sections of Duralumin used totals 20 miles, the length of wire used in the hull amounts to 53 miles, and the area of fabric required is 30,000 sq. yards. About 1,250,000 rivets have also to be put in, and over 600 drawings are required. These facts doubtless go a long way to account for the fact to which we referred in our first article, viz., that very few firms in this country are capable of undertaking the complete construction of a large rigid airship. The difficulties of the work during the war were naturally enhanced by the shortage of skilled labour, but a very high degree of productive efficiency was eventually obtained by the employment of women. Of the hands employed by Messrs. Vickers on airship work, 65 per cent. were females, who carried out practically all the operations of drilling, riveting and wiring. Women also did a considerable amount of work, of a comparatively skilled nature, in connection with the erection of the hull framework, and in assembling the cars.

Another subject to which Messrs. Vickers' airship department have recently given considerable attention, is the metal construction of structural parts of aeroplanes and seaplanes. As is well known, the wing spars, and other important parts of aeroplanes, are usually constructed of spruce, and the enormous demands for this material during the war having produced a serious shortage in this timber, the question of finding a satisfactory substitute became of paramount importance. In August, 1918, the firm was requested to consider the matter of metal construction, and particularly to give immediate attention to the design and construction of metal wings. The experimental work already carried out by the firm in connection with light girders for rigid airships enabled them to proceed with the experimental construction of aeroplane wings in metal without much preliminary work. The only metals that could be employed for this work were high tensile steel and "Duralumin," and tentative designs were made in both metals to suit various types of machines. Owing to many practical difficulties with steel, such as the impossibility of obtaining thin sections straight and free from twist, owing to the necessity for heat treatment after rolling, the use of this metal was temporarily abandoned, and it was decided to proceed with "Duralumin" spars until suitable steels could be produced. Test spars were therefore put in hand suitable for the Handley-Page Vee machines, "Avro" 504 K. machines, and the "Vimy" bomber, and the results of tests on the full-size spars showed that they could be made in Duralumin equal in strength to, and of 75 per cent. to 80 per cent. of the weight of, the corresponding spars in spruce. A number of complete wings for Avro machines have since been made in Duralumin, and full-scale loading tests carried out show that the wings for these machines can be made of only 75 per cent. of the weight of complete wings constructed of timber in the usual way. The firm is proceeding with the manufacture of Duralumin wings for the largest types of aeroplanes now being designed and built, and there can be little doubt that the performance of such machines will be considerably improved by the metal construction of the wings, as also will be their reliability and durability. We may also mention that Messrs. Vickers are now engaged on the design of a very large seaplane, the structure of which will be built entirely of Duralumin. Unfortunately, we are unable, at present, to give details of this machine, but it may be of interest to state that its total lift will be 50 tons, of which at least 20 tons will be made up of fuel, oil, passengers and goods. The calculated speed is 100 m.p.h., and the machine will be built in the Walney airship shed.

HÉROULT FURNACES IN THE UNITED STATES.—We read in *The Iron Age* that a decision has been reached as to the type of electric furnaces to be used in the Navy ordnance plant at Charleston, W., Va. Two 30-ton Héroult furnaces will be installed and will be used in conjunction with open-hearth furnaces for duplexing. It is expected that it will be possible to produce as high as 38 tons to a heat in these furnaces, with heats every 3 hours.

LATHE FOR CUTTING SCREW THREADS ON GAUGES.

THE lathe which has been specially built by Drummond Brothers, Limited, of Guildford, for the production of accurate threads on high-class screw gauges is the outcome of the company's desire to meet the requirements of the various Government Departments and more particularly those of the Ministry of Munitions for a standard machine which will not only ensure accuracy of pitch of the thread cut on the gauge, but will continue, under proper working conditions, to reproduce the screw on the gauges to the required

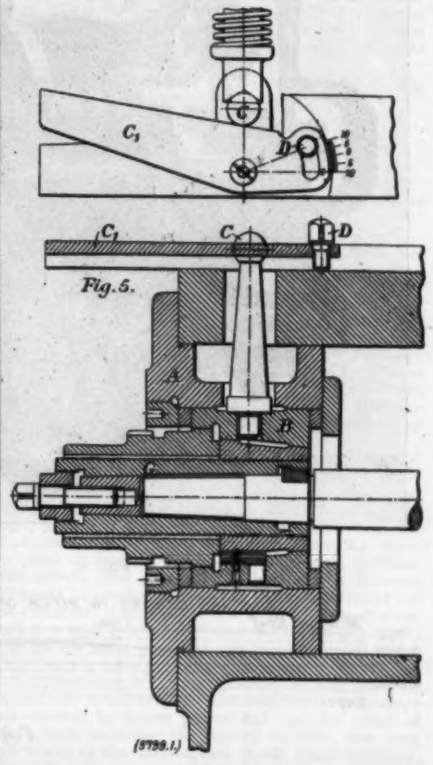


Fig. 5.

FIG. 6.

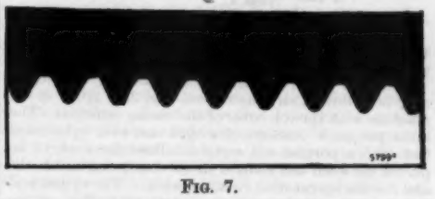


FIG. 7.

limits so long as the lead screw fitted to the lathe is itself within the narrow limits of inaccuracy necessary to attain this requirement.

The company decided, after full consideration, to mount the master lead screw on the axis of the lathe; by adopting this principle the travel of the work is directly controlled and the errors due to the working slides, gear wheels and thrust bearings are entirely eliminated.

The lathe for the production of the thread on plug gauges is shown in Fig. 1, on Plate LXIII. It will take work up to 4 in. diameter by 6 in. long, and the maximum length of screw which can be cut is 3 in. The threads on internal or ring-screw gauges can also be cut on this lathe, but it is necessary, for this work, to reverse the tool and, therefore, if large quantities

LATHE FOR CUTTING SCREW-THREADS ON GAUGES.

CONSTRUCTED BY MESSRS. DRUMMOND BROTHERS, LIMITED, ENGINEERS, GUILDFORD.

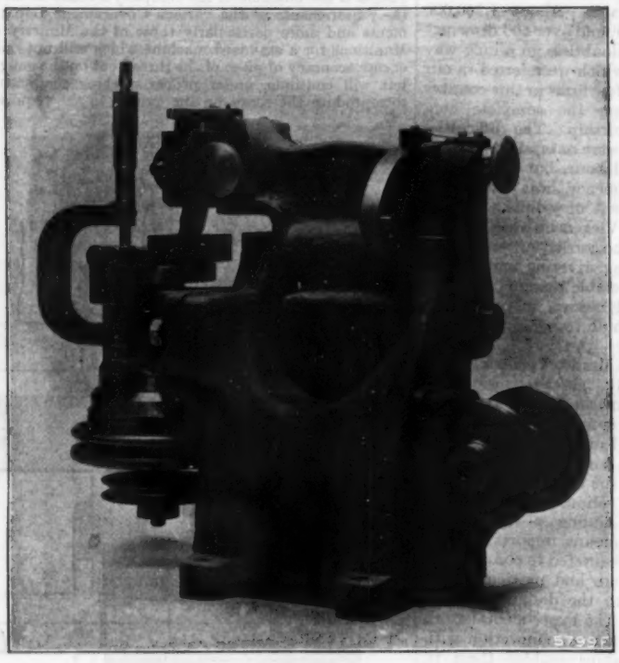


FIG. 8.

FIG. 9.

Fig. 12. ERRORS IN PITCH OF ONE TRIAL SCREW. F ·66 m/m. British Association Screw Thread

Fig. 13. ERRORS IN PITCH OF A TRIAL SCREW. 26 THREADS PER INCH
Ref:- M.S. 52 189 M.7025

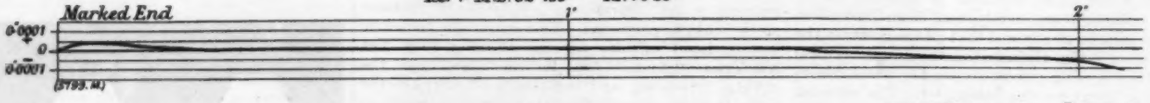
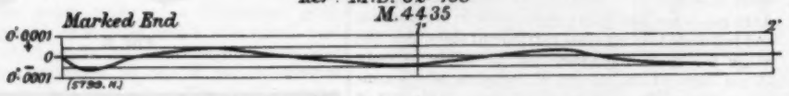
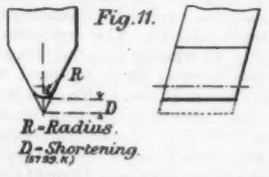


Fig. 14. ERRORS IN PITCH OF ONE TRIAL SCREW. 14 THREADS PER INCH
Ref: M.S. 52-158
M.4435





are to be made, it is desirable to use the special machine, of which particulars are given later on.

In order that the leading features of the design may be followed an illustration, Fig. 2, is given of the machine with the top cover of the casing removed. The lathe proper F consists of a rigid cast-iron cylindrical bed with a portion cut away to allow the work to be placed between the centres in the head and tailstocks and for the operator to view the work. The cylindrical bed is ground true and concentric with the centres and floats in the machined hollow casing which supports the driving mechanism and the stationary compound slide-rest, the whole being mounted upon standards at a suitable height above the floor for ease of working.

The drive, obtained from a three-cone countershaft, is belted on to the cone R, and thence, by the open and crossed belts and clutches, drives the spiral gear E. The pulley on the crossed-belt drive is of larger diameter to give a fast return motion to the lathe bed.

The lathe spindle is driven from the spiral gear E, the bearings D1 and D2 for which are supported in the casing and free from any bearing on the spindle of the lathe.

The clutches are controlled by the hand lever P, and are operated automatically by adjustable stops I and J, which respectively release the forward and reverse clutch and place the handle in the neutral position at the end of each cut; the lathe may be stopped promptly at any position of the cutting tool by drawing out the small knob Q, which instantly releases the clutch.

In order that the thread may be cut upon the gauge, the lathe bed F has to be moved bodily in front of the fixed cutting tool H. This motion is obtained directly from the master lead screw G, which is 1¼-in. diameter by 5 in. long, and fitted concentric with and on a tapered prolongation of the lathe spindle, as shown in Fig. 5. A separate master lead screw is required for each pitch of thread to be cut, the interior is therefore tapered and pushed on to the end of the lathe spindle; this secures interchangeability, and ensures that the screw is truly assembled. The master screw G is engaged with its nut, which is held in the nut-holder B, the nut-holder being coned to receive the nut and mounted in the nut-holder container A.

The compound slide rest is stationary and rigidly clamped to the casing by means of levers L and O after the tool H has been set up to cut the screw. The upper slide, which enables the tool to be fed into and withdrawn from the work, is controlled by a spring which locates the slide and governs the depth of cut, the stop has therefore to be set to the required depth of cut. In order that this stop may be accurately set by the micrometer head M the lever L is used. This lever performs three distinct functions—in the first it locks the slide to the rest, in the second it withdraws the cutting tool from the work, and in the third by compressing the spring takes the weight off the stop, which allows the fine adjustment by micrometer head M to be made without straining any of the mechanism. The lever L is shown in Fig. 2 in the position in which the slide is locked; it has to be pulled from left to right to unlock the slide, and on continuing this motion the second and third positions are obtained. The side adjustment of the cutting tool H is given by means of the micrometer head N; after this slide has been set in its correct position it is rigidly clamped to the bracket by lever O.

The attachment by means of which compensation for the shrinkage or lengthening of the steel during the hardening process can be made is shown in Figs. 1 and 5. The lever C in Fig. 5, is fixed into the nut-holder container A; therefore, if the nut-holder B is made to rotate gradually in a positive or negative direction during the progress of the master lead screw G on the nut, it will cause the former, and therefore the work, to be advanced or retarded through the amount of movement given to the lever C. In the lathe the movement of lever C is effected automatically by pressing the ball of lever C (Figs. 2 and 5) against

LATHE FOR CUTTING SCREW-THREADS ON GAUGES.

CONSTRUCTED BY MESSRS. DRUMMOND BROTHERS, LTD., ENGINEERS, GUILDFORD.

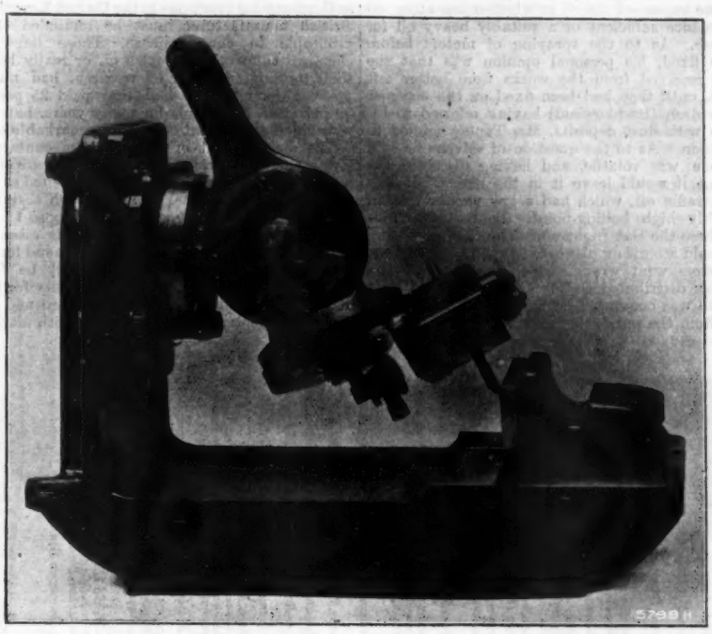


FIG. 10.

TABLE I.

Whitworth Thread Tools.

T.P.I.	R.	D.	T.P.I	R.	D.	T.P.I.	R.	D.
6	0·0229	0·0258	14	0·0098	0·0110	27	0·0051	0·0057
7	0·0196	0·0220	16	0·0086	0·0097	30	0·0046	0·0051
8	0·0172	0·0194	18	0·0076	0·0086	32	0·0042	0·0047
9	0·0152	0·0171	19	0·0072	0·0081	36	0·0038	0·0042
10	0·0137	0·0158	20	0·0069	0·0077	40	0·0034	0·0039
11	0·0125	0·0141	22	0·0063	0·0071			
12	0·0114	0·0128	24	0·0057	0·0064			
13	0·0106	0·0120	26	0·0053	0·0060			

B.A. Thread Tools.

No.	R.	D.	No.	R.	D.	No.	R.	D.
0	0·0072	0·0103	8	0·0031	0·0044	16	0·0014	0·0020
1	0·0064	0·0092	9	0·0028	0·0039	17	0·0012	0·0017
2	0·0058	0·0083	10	0·0025	0·0036	18	0·0011	0·0015
3	0·0032	0·0074	11	0·0022	0·0032	19	0·0010	0·0014
4	0·0047	0·0068	12	0·0020	0·0029	20	0·0009	0·0012
5	0·0042	0·0060	13	0·0018	0·0026	21	0·0008	0·0011
6	0·0038	0·0051	14	0·0016	0·0023	22	0·0007	0·0009
7	0·0034	0·0048	15	0·0015	0·0021			

the compensator bar C1, Fig. 5, and also seen on the left in Fig. 1. The amount of inclination given to this bar to true parallelism with the centre line of the lathe is set by means of the smaller square-headed screw D.

The operating handles are all brought to the front of the machine, and in a handy position for the operator.

In Figs. 3 and 4 are shown the special lathe modified for the production in quantities of ring-screw gauges, or any special gauge having an internal thread. The design is in essential details the same as that shown in Fig. 1, with the exception that it has not a tailstock and the slide rest is supported upon a facing on the end of the casing. The work is fixed on to the face-plate on the lathe spindle and the slide rest can be swivelled clear of the work, as shown in Fig. 4; this gives free access to the work for the purpose of setting and manipulating any special tools and for gauging the thread being cut. The slide rest is positioned by pressing it against the square face X and locking it rigidly to the bed by means of the levers Y and Z.

The illustration, Fig. 3, is made from the position in which the operator sits, and about which all the operating handles as well as the micrometer heads on the compound slide rest are conveniently placed.

The company have adopted a modified form of Whitworth thread on their standard master lead screws; the departures from the standard are that the crest of the thread is flat and the radius at the root is always less than that of the Whitworth thread. The

TABLE II.

T.P.I.	Whitworth. Helix Angle.	Whitworth. Sine for 5-in. Sine Bar.	Metric. Pitch MM.	Metric. Helix Angle.	Metric. Sine for 5-in. Sine Bar.
	° ′			° ′	
6	3 2	0·2646			
7	2 36	0·2268	0·75	0 32	0·0466
8	2 17	0·1992	1·0	0 43	0·0626
9	2 2	0·1775	1·25	0 54	0·0783
10	1 49	0·1584	1·5	1 5	0·0940
11	1 39	0·1439	1·75	1 15	0·1096
12	1 31	0·1324	2·0	1 26	0·1253
13	1 24	0·1222			
14	1 18	0·1134	2·5	1 48	0·1566
16	1 8	0·0995			
18	1 1	0·0884			
20	0 55	0·0796			
22	0 50	0·0573			
24	0 45	0·0655			
26	0 42	0·0611			
27	0 39	0·0574			
30	0 36	0·0530			
32	0 34	0·0497			
36	0 30	0·0442			
40	0 27	0·0398			

B. A.

B.A. No.	Helix Angle.	Sine for 5-in. Sine Bar.
	° ′	
2	0 35	0·0507
4	0 28	0·0414
6	0 25	0·0334

portion of the thread shown in Fig. 6, page 799, is the company's 14-thread per inch, whilst Fig. 7 is a No. 6 B.A. thread; these figures are reproduced from actual threads projected on to a screen.

In order that the vee-pointed cutting tools for use in the slide-rest may be accurately made at a reasonable cost, the firm designed a set of valuable appliances comprising a machine for forming the radius on the point of the V-tool shown in Fig. 8, the special fixture for grinding the top and flanks of the tool, Fig. 9, and the special angle block shown in Fig. 10

These have proved to be most useful, and the design is such that careful workers can be trained to use them accurately and produce good tools without the help of a highly-skilled tool-room hand. The instructions issued by the firm for working the point-lapping machine, Fig. 8, are: (*a*) Set the stop pins to the required angle of the cutting tool; (*b*) set the lap with the vee-block plate in position to measure, by the micrometer seen in the illustration, over the plate and the fixed ball 1·5 in. less the value of (D + R) for the pitch of screw to be cut; (*c*) set the graduated collar on the elevating screw to zero; (*d*) set the V-tool in the vee-block and lock it in position; (*e*) remove the vee-block and plate, and raise the lap the thickness of the plate 0·375 in., then reset the graduated collar to zero; (*f*) start the machine and gradually raise the lap, reading the required value of dimension D on the graduated collar (the dimension D is obtained from Table I). Whilst the process of truncating the point by lapping is in hand the head of the machine is swung between the stop pins to produce the radius.

The values of R and D, Fig. 11, are given in Table I for the Whitworth and B.A. threads.

The grinding and lapping fixtures, Figs. 9 and 10, are hand-operated. The fixture, Fig. 9, is set up ready for bolting on to the table of a grinding machine, on which it is located by accurately-prepared tongues; whilst in Fig. 10 the same fixture is set in the special angle block for the lapping operation; the lapping plate is maintained in its square and upright position by the block, which is accurately guided in the slots shown.

The instructions issued by the company for setting the grinding and lapping fixture are as follows:—

To set fixture the following data are required:—
Sine of helix angle of thread × 5 in.
Sine of half the full angle of tool flanks × 5 in.
Cutting angle of tool, 15 deg.

Set arm marked "A" to helix angle of thread by sine bar.
Set arm marked "B" to half the full angle of tool flanks by sine bar.
Set tool block graduated base "C" to 15 deg.

After grinding or lapping, one flank of tool, reverse tool block and grind other flank.
To grind top of tool set tool block base to zero, other settings remaining as before.
Chart gives sines of angles of tools for Whitworth, metric, and B.A. threads, and helix angles are given for a work diameter of 1 in.

The master lead screws supplied by the company are made at their works, great care has to be exercised in producing the threads to the correct pitch and form, and as the screw is hardened the necessity for precision and special methods will be readily appreciated by those responsible for similar work.

All the screws are thoroughly tested by the company, and we have seen a number of the certificates issued by the National Physical Laboratory which are uniformly good. The curves in Figs. 12, 13 and 14 have been reproduced from those received from the National Physical Laboratory, and show the errors in pitch of the trial screw over the lengths specified. We should here mention that under the National Physical Laboratory system the test is not carried out on the actual master lead screw but on a piece of work, called a trial screw, the thread on which is actually cut in the lathe in which the master screw, whose inaccuracy is being investigated, is mounted.

In conclusion it is only necessary to add that the special and novel details in the design of the machinery are covered by letters patent and that the whole of the plant, including the special fixtures, has been purchased by the Birmingham Small Arms Company, Limited.

THE INSTITUTION OF GAS ENGINEERS.

(*Continued from page* 780.)

THE next business was the report of the Life of Gas Meters Joint Research Committee, which is composed of representatives of the Institution and the Society of British Gas Industries. Mr. J. G. Taplay, chemist to the committee, submitted the report, which described some preliminary work which had been carried out on the internal corrosion of mains and services. At the Institution's meeting last autumn, in a paper on the corrosion of dry gas meters, attention was given chiefly to the action of certain compounds, found to exist in the gas, on meter leathers and valves, particularly during the period of manufacture under the stress of war conditions. A reference was made to the corrosion of the metal parts of meters; and it was subsequently felt that this part of the subject should be investigated. Cases were also brought to notice where dust had been found in mains, services, governors, and meters by gas undertakings, the majority of whom were distributing gas under high pressure. Many of the cases were brought to light by an accumulation of dust in high-pressure governors, and the committee were indebted for information to Mr. H. J. Donkin, whose firm had had to bear the brunt of the trouble. Subsequently it was found that similar experiences had occurred in systems of low-pressure distribution.

It was necessary at the outset to ascertain whether such dust, found in the distributing system and composed chiefly of oxide of iron, was, or was not, oxide carried forward from the purifiers. From different parts of the country samples of deposits from mains and services had been received for analysis. None of them contained peat as found in native bog ore, sawdust due to the use of artificial oxide, or alumina. These deposits were found to contain much more ferric ferrocyanide (prussian blue) than was contained in purification oxide. From these facts it would appear that the dust deposits did not have their origin in purification oxide, and it therefore followed that corrosion of some sort had been taking place. The fact that

many of the cases were reported as having occurred since oxide alone had been used in the purifiers was of interest because (1) absence of lime in purification accounted for the passing forward of the bulk of the hydrocyanic acid found in the gas; (2) small but varying amounts of this hydrocyanic acid would be extracted by oxide purification. Such action was hindered by revivication *in situ*, especially when an excessive proportion of air was passed into the purifiers. Another consideration was the impoverishment of modern gas in respect of its oily constituents, affecting the matter again in two ways: (1) Condensation of watery content took place more readily in mains and services, owing to the lack of carrying power exercised by oily vapours; (2) the distribution system lacked the protection afforded by the old-time natural lubricating properties of the gas.

In pointing this out, Mr. Taplay stated it was not desired to raise undue alarm, for the issue was comparatively straightforward, and new conditions of gas-making, which had come to stay, could be reasonably supplemented for the protection of plant. Chemically, hydrocyanic acid was the primary agent of corrosion, the prejudicial effects of which were much increased by the presence of oxygen, while the carbon dioxide played a lesser part. Physically, no corrosion would be likely to take place except in the presence of moisture; and, as a matter of fact, it was at the "dew point" that corrosion mostly occured. The reason why there were more cases of corrosion with high-pressure than with low-pressure distribution probably arose from the deposition of moisture from the gas in the mains under the higher pressure. A visit had been made to a works where gas was compressed to 50 lb. per square inch, cooled, and subsequently expanded into the mains at 5 lb. only. All mains and services were laid without fall and without receivers. No condensation took place in the district, and no trouble had occurred either in the nature of corrosion or naphthalene deposit. This method was known as the "Helps" system. The primary objects of the high compression were doubtless storage of gas under pressure, a reserve of pressure for emergencies, and certain advantages of intermittent pumping; but it was evident that consideration of the vapour content in the gas had also entered into the scheme. This provision for the removal of water from the gas probably had results beyond those originally anticipated; for the condensed water brought down with it certain salts which played a direct part in corrosion. An analysis of the aqueous liquor taken from the compression tank gave the following result:—

	Grains per Gallon.
Ammonium thiocyanate	31·0
Ammonium ferrocyanide	15·0
Ammonium sulphate	4·4
Ammonium sulphide	1·6
Ferrous sulphate	1·3
Carbon dioxide	31·5

The elimination of ammonia, with consequent prevention of indirect means of corrosion, was, in normal times, a matter of course for all gas undertakings; but cyanogen washing was the exception rather than the rule. The present investigation dealt with undertakings where the removal of hydrocyanic acid was not carried out; and the conclusion therefore was either that this impurity should be removed or protection given to the internal surface of the distributing plant. If the latter were adopted, the remedy was the same as previously advocated for use with dry meters, viz., lubrication by atomised paraffin oil. The engineer of a works where this had been done reported that after spraying petroleum into the gas at the works the accumulation of black deposits on the district sensibly diminished. The same remedy was applied to the high-pressure system, petroleum being introduced on the outlets of the compressors with similarly beneficial results.

Mr. B. R. Parkinson, who has been acting with Mr. Taplay in these investigations, said the committee had written on the subject to about 40 engineers in the country, from whom about 20 replies had been received. A great number of condensates and deposits had been analysed by Mr. Taplay, and the work was proceeding. A letter from Mr. H. R. Wimhurst, of Bury St. Edmunds, was read, giving his experience with oil spraying, which at first had had to do with naphthalene troubles. He was not a believer in vaporising the oil, but held that the oil should be in a state of mechanical suspension; and that the spraying process should do much to prevent the interior corrosion of mains and services by greasing the interior surfaces.

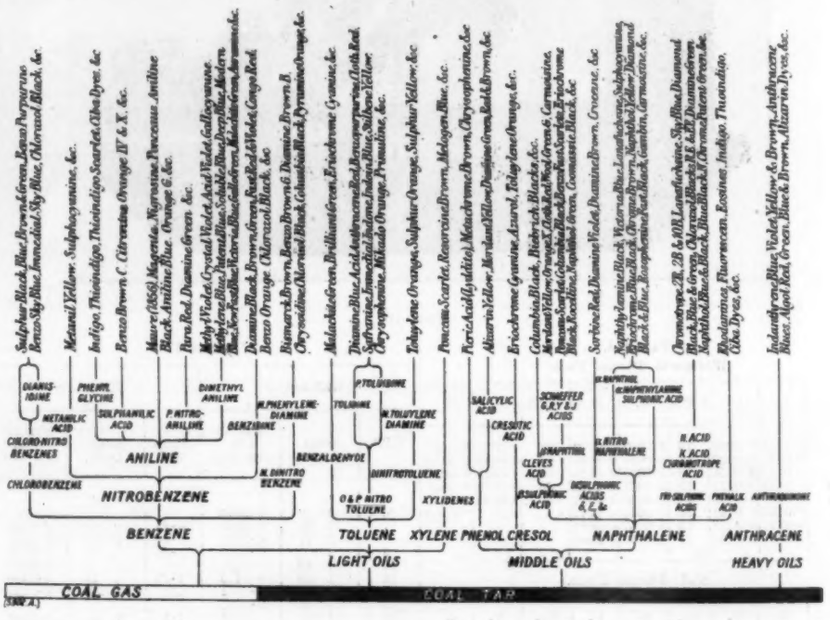
Mr. C. F. Botley (Hastings) referred to the process with which he was identified, and said at Hastings there was entire immunity from naphthalene troubles or mains corrosion.

Mr. R. E. Gibson (Liverpool) had tried solvene some years ago for the treatment of naphthalene, but while beneficial in one way, it was found that it threw down the naphthalene in the mains and services. They had for some time been spraying the mains with paraffin with very excellent results.

The president pointed out the necessity of using an oil of the right composition, one which was as near the vapour tension of naphthalene as possible.

Mr. Thomas Glover (London) thought it was possible, whether one vaporised the oil or whether one atomised it, to introduce sufficient of a suitably heavy oil for the purpose. As to the spraying of meters before they were fixed, his personal opinion was that the meters as received from the works were better left untouched, until they had been fixed on the services.

Dr. Davidson (Huddersfield) having referred to his experience with dust deposits, Mr. Taplay replied to the discussion. As to the question of solvene he said that solvene was volatile, and having dissolved the naphthalene it would leave it in the mains. It was not like paraffin oil, which had a low vapour tension and a fairly high boiling-point. In the particular district where the Gas Light and Coke Company were using the cold atomising plant, only about 1½ per cent. of the meters went wrong, which was because the paraffin was distributed so successfully. As to dust deposits, he was convinced that the chief trouble did not arise from the purifiers.



The report of the committee was agreed to, and the proceedings of the second day came to an end.

On the following morning (Thursday), Dr. W. B. Davidson gave an abstract of his paper on "The Inter-relation of the Gas and Dye Industries." It was illustrated by a few experiments, and by a beautiful collection of samples provided byBritish Dyes, Limited. After referring to the early history of the gas and dye industries, which he said reflected great credit on the engineers and chemists of this country, Dr. Davidson referred to what Germany had done. The gas consumption per head of the population in Great Britain and Germany was in the ratio of about 4 to 1. This country, therefore, had a very great advantage, not only over Germany, but over all other countries in the potentialities of her coal-tar industry.

Although as early as 1792 Murdock inaugurated the commercial application of coal gas, it was not until 1820 that any chemical discovery in connection with its by-products was recorded, when Garden isolated naphthalene from coal tar. Benzene was discovered by Faraday in 1825; aniline by Unverdorben in 1826; anthracene was isolated from coal-tar in 1833 by Dumas and Laurent. Runge, a year later, obtained also carbolic acid, quinoline and pyrrol. In 1847 Mansfield produced a process for making nitro-benzene, but the greatest event of these times was Perkin's synthesis in 1856 of the dyestuff aniline purple, afterwards called mauve, the first coal-tar colour. The discovery was accidental, as this famous chemist was at the time vainly endeavouring to synthesize quinine by the oxidation of aniline.

The causes of British want of progress in the dye and fine chemical industries were dilated upon. The late Sir W. H. Perkin, who sold his dye factory in 1874, after a successful business career of seventeen years, stated that one of the causes which influenced him in returning from industry to private research was the dearth of suitable chemists. Most of the German university graduates in chemistry went straight to the chemical works after finishing their course. In some works there were as many as 250 research chemists, the principal men getting very handsome salaries. In the year 1913 there were about 20 research chemists in Germany for every one in the United Kingdom. The British manufacturer must be reminded that it is profitable to court science. Those large German chemical companies, in spite of, or really because of, their formidable outlay on research, had made huge profits; for not only had they paid 25 per cent. to 30 per cent. dividends for many years, but they had written-off their plant costs to a remarkable extent.

The development of the platinum contact process for making sulphuric acid; the manufacture of artificial indigo, and of synthetic ammonia were cited as examples of successful enterprise. As to British activity, what chemical industries should be developed? The dye industry must certainly be classed as essential, and also the gas industry. The possible demand for benzone toluene and carbolic acid, must not be forgotten. Again, ammonia was a national necessity for food production, and would also be used more and more in chemical industry. In combination with nitric acid to form nitrate, ammonia might be looked upon as high explosive. Frequently the by-products of the manufacture of one chemical conveniently satisfied the requirements of another process, and the two processes became mutually helpful. In a chemical works making dyes and allied chemicals the main expense was the plant—labour charges being a secondary consideration. Referring to the constituents of coal-tar necessary for dye making, Dr. Davidson said only half a dozen or so were of commercial importance, viz., benzene, toluene, xylene, phenol (carbolic acid), naphthalene and anthracene. He gave figures relating to the output of German tar distilleries and called attention to the extremely large increases in production of benzol and toluol in 1913, which were very remarkable and suggestive.

In concluding his paper the author said it would be impossible to describe, even the more important commercial derivations of coal-tar products, but reference to the accompanying diagram would give some information as to their relations one to the other.

A vote of thanks was accorded to Dr. Davidson; a message of greeting from the Italian Gas Association was announced; and then Mr. A. E. Broadberry, M.Inst.C.E., proceeded to give his paper on "The Application of Reinforced Concrete to Purifier Construction," with which we shall deal in our next issue.

(To be continued.)

FRENCH TECHNICAL WORDS AND PHRASES.—We have received from Messrs. E. Marlborough and Co., 51, Old Bailey, E.C. 4, a copy of the third edition of this English-French and French-English dictionary, by Mr. John Topham, barrister-at-law. This is a handy volume, measuring 6 in. by 3 in., containing over 300 pages of technical and business terms and phrases used in commerce, arts, sciences and trades. It is carefully got up, clearly printed, and will prove useful in practically every industry and occupation. Its price is 5*s.* net.

SOME POINTS IN THE MANUFACTURE OF FILES.*

By GEO. TAYLOR (Sheffield).

(*Concluded from page* 771.)

Cutting.—In speaking of file-cutting, Theophilus (eleventh century) informs us that it was done by means of a double-edged cutting hammer, or a notching iron. The two-edged hammer was used up to the fifteenth century, when it gave place to the hammer and chisel. Early in the sixteenth century Leonardo da Vinci invented the first cutting machine. Following on this in 1627, Mathurin Jousse invented another. Many other inventions followed, but with little success. Although machines had been used to some extent in France, it was not until about 1875 that they began to be used generally in Sheffield. Since their introduction hand-cutting has died down, and is at the present time a relatively unimportant industry. It is confined mostly to small files which might be distorted on the machine, and special shapes. Although there was formerly great controversy as to the respective merits of the hand and machine cut file, little interest is now taken in the subject.

Fig. 13.—Machine-cutter's chisel.

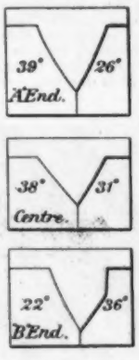


Fig. 14.—Hand-cutter's chisel. This chisel was found to be unevenly whetted, and so the angles were measured at each end and in the centre.

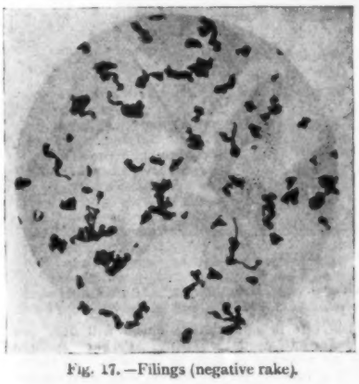


Fig. 17.—Filings (negative rake).

The machine-cut tooth is more regularly formed, but does not vary in shape from the hand-cut tooth to any great extent. It was, and is, commonly supposed that the hand-cutter worked with a sharper chisel than the machine man, the former having what he called a "thin" and the latter a "thick" chisel. The "thin" chisel of the hand-cutter after being ground and whetted "long and short"—that is, with a long side and a short side—was supposed to give a forward rake to the tooth of the file. The opinion arose owing to the difference in the shape of the tools. In the important part of the tool, the cutting edge and angle, there is little or no difference. The hand-cutter's chisel may have a thin web, but it is the angle of his whetting that determines the rake of the tooth, and this angle is practically the same on the machine chisel as on the hand-cutter's tool (see Figs. 13 and 14). The hand-cutter's was found to vary along its length, so the angles were measured at three points. This question of angles is extremely interesting and important, because the rake of the tooth depends on the angle of whetting of the chisel in conjunction with the angle of inclination of the bed on which the file rests, or the machine head in those cases where the bed is horizontal.

The machine file-cutter grinds and whets his chisels for himself just as does the hand-cutter, and in just the same way. He endeavours to whet with equal angles for the overcut and with a "long" and a "short" side for the upcut. He does not know usually what the angles are that he makes, neither does he know the angle of inclination of the file bed or the machine head. His past experience and the way he has been taught are his guides. Consequently he may never whet the same angle twice, and this accounts to some extent, particularly if he is careless or hurried, for the differences which are to be seen in the rake of file teeth.

All commercial files, with the exception of certain milled varieties, have teeth which slope more or less backward. Fig. 15 may be taken as a fair sample of the teeth to be found on such files, the arrow indicating the direction in which the file is intended to move. Let us suppose now that the file-cutter who is working on bastard cut files endeavours to whet his chisel with equal angles, and to include an angle of 60 deg. If such a chisel operated in a machine whose bed slopes at an angle of 15 deg. to the horizontal, it is clear that the tooth formed must have a rake of minus 15 deg., because

$$15 \text{ deg.} - \frac{60 \text{ deg.}}{2} = -15 \text{ deg.}$$ (See Fig. 16.) The observed average rake of a large number of commercial files of English, American, and continental origin was found to be minus 8 deg. This form of cutting edge is certainly very strong, and the tendency is to vary its obtuseness according as the blanks are more or less soft. The greatest negative rake we have measured was 24 deg., and the greatest positive rake 7 deg.

When first the question of rake of file teeth began to be investigated, there were many protestations that a section and take an enlarged photograph, but this involves the destruction of the file. Fairly satisfactory results can be obtained, however, by the use of the instrument illustrated in Fig. 19, if the following directions are observed: Blacken a portion of the file over a candle flame. Place the base, A, of the instrument over the blackened portion so that it stands at right angles to the upcut. Take the fine needle, E, and make a bright mark along the bottom and close up to the face of the teeth; the use of the lens enables this to be done with considerable accuracy and uniformity. Whilst the mark is being made and the tube, B, is tilted forward, the face of the tooth can be seen. Now rotate the tube slowly backward until the line at the base of the teeth just disappears from sight. This happens when an imaginary line passing through the small eye aperture, C, and the centre of the lens, D, lies along the face of the tooth. A pointer attached to the tube and moving over the protractor scale gives the inclination of this imaginary line to the vertical, and indicates to what extent the rake of the tooth is plus or minus. The question of the rake has been dealt with out of its rational order, because it is the most important item the manufacturer has to settle in relation to the shape of the file teeth.

The next point to be considered is the overcut. The object of the overcut is to provide a number of furrows which will divide the subsequent upcut into a convenient number of separate teeth, and we can imagine that the shape and also the size of the furrows might be allowed to vary considerably without impairing the efficiency of the teeth. I am not aware that this point has been investigated experimentally. From certain experiments that I have made, although uncompleted, I am convinced that variation from the present standard will lead to the production of files whose cutting efficiency is considerably higher than that obtaining at the present time. The number of teeth per inch in the overcut as compared with the upcut must be considered very carefully, as it certainly has an important bearing on the efficiency of files.

The shape of file teeth as viewed from the face is determined by the overcut. Now it is customary to smooth down the ridges raised during the process of overcutting, either by filing them or by the use of an emery-wheel. This is a process where the greatest care and attention is needed, because its influence is second in importance only to the rake. Unfortunately, this is one of the points most often overlooked, and very very carelessly dealt with. It is the source of almost infinite variation in the shape of file teeth, and no attempt has been made, so far as I know, to standardise the operation.

If the ridges are made too flat the metal does not rise into a proper tooth when the file is upcut, and when the teeth of such files are photographed one sees clearly (Fig. 20, page 804) that such teeth may be strong, but they are not sharp, and the file will need to be pushed by a strong man if it is to be used on broad surface work. On the other hand, if the upcut is filed insufficiently, the tooth formed by the upcut will flow into a sharp point, as illustrated in Fig. 21. This form of tooth is much

Fig. 15.—Teeth sloping backwards. File teeth with negative rake.

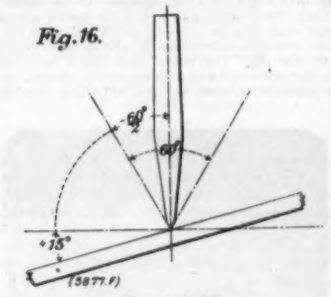


Fig. 16.—Angle of rake.

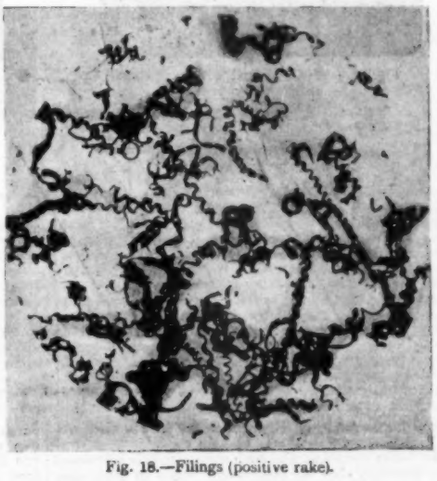


Fig. 18.—Filings (positive rake).

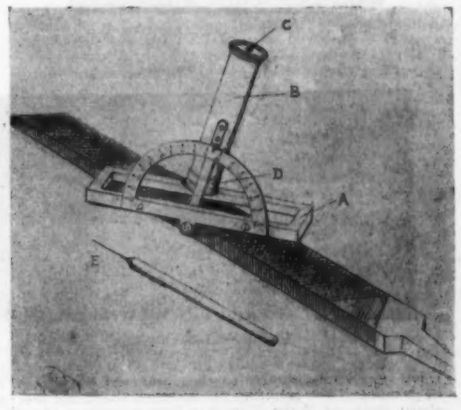


Fig. 19.—Instrument for measuring rake.

* Paper read before the Iron and Steel Institute, on Friday, May 9, 1919.

too delicate for general use, and although it may cut well on broad, flat surfaces like lathe beds, for example, where the pressure exerted by the man per tooth is necessarily small, there is always a tendency for the teeth to strip or break off. For use on narrow surfaces it would be of little value, because all the teeth would break. This particular file when tested with the Herbert machine, on the standard Herbert bar, cut faster than any file we have seen, but did not last long.

When the overcut is filed down, no matter whether it be by means of a file or emery-wheel, the ridges should be left with smooth tops. The scoring action of both file and the emery-wheel is detrimental to finished file, in so far as a tendency is given for the teeth to develop cracks. These cracks weaken the teeth, and they readily break off in use. Fig. 22 shows a file with scoring marks left in the ridges of the overcut, and Fig. 23 shows the resulting cracks in the teeth. Great variation exists in this respect between files made by different firms, and there is no remarkable uniformity in files made by the same firm. I do not presume to state to what extent the overcut should be filed. That would depend more or less on the varying degrees of hardness in the file blanks and the force of the blow exerted, and the overcut would have to be filed accordingly.

As already stated, the upcut serves to make the metal flow up into the final tooth shape. If the overcut has been filed irregularly, there will be teeth which vary in shape and also in efficiency. They will be flatter or more rounded, according to the degree of filing on parts of the file. On some files which have had the overcut flattened by hand over an emery-wheel, variation of the pressure exerted by the man has resulted in a wavy appearance similar to that produced sometimes in grinding. The resulting file has then sharp and less sharp teeth, or if the filing has been excessive, blunt and more blunt teeth, and the filing efficiency of such files may thereby be reduced 50 per cent.

If a file has blunt teeth it is an extravagant waste of both energy and time, and no matter how little has been paid for it, it is likely to be a dear article. The shape and rake of file teeth should, without doubt, differ according to the kind of work upon which they are to be used, just as turning and planing tools are made with differently shaped noses; but in every case where it is intended that a file should be used as a cutting tool the teeth should have a positive rake. To do this the cutting angle of the chisel must be whetted to such a degree that, taken in conjunction with the angle of bed or machine head, a forward tooth will result. By way of example, we will suppose that the machine bed is sloping at an angle of 15 deg. (see Fig. 16), and we desire to produce a positive rake of 5 deg. It is obvious, therefore, that we must whet the chisel to form a cutting angle of 10 deg. on that side which raises the face of the tooth: 15 deg. – 10 deg. = 5 deg. This is one of the most important problems in file manufacture, and no satisfactory solution can be obtained until machines are installed in factories for whetting chisels, to any desired angle. Fig. 24 shows angles of machine chisels, two of which were taken at random. *a* was for upcutting second cut files; *b* for over-cutting bastard cuts; and *c* for producing a positive rake on bastard cuts. *c* was ground and whetted on a special machine for the purpose.

The force of the blow exerted by the cutting machine should be sufficient to strike right to the bottom of the overcut. If this is not done the tooth formed (see Fig. 23) is weaker than it need be, and breaks off more easily at the root. It is easy with a good hand lens to see whether this has been properly done, and at the same time the shape given to the cutting face of the tooth can be observed. The lens which forms part of the instrument shown in Fig. 19 is detachable, and is especially suitable for the above purpose, as it brings a large field evenly into focus.

There remain now to be considered the three important questions of (1) angle of clearance; (2) inclination of the angles of overcut and upcut to the axis of the file; and (3) the number of teeth per inch. With regard to the clearance angle, I am in complete agreement with Mr. Edward G. Herbert, and cannot do better than quote his remarks on this point in conjunction with the diagrams in his paper on "The Testing of Files and Tool Steel." Mr. Herbert says:

"The slope of the back face of the tooth, or clearance, is very difficult to measure, because it is not a plane surface (see Fig. 25). It is probably very important in relation to the durability and to the total output of work. A file which has worn out has the ends of its teeth flattened or rounded. When the area of contact of the teeth with the work attains a certain value, great pressure is required to cause the teeth to penetrate the metal. The amount of work that can be got from a file, therefore, depends largely on the volume of tooth available for wear before this limiting area is attained. Fig. 25 shows two file teeth with different clearance angles. The part of the tooth available for wear is shaded, and it is evident that the tooth with greater clearance presents a much greater volume of tooth for wear before the limiting or slipping area is presented to the work. There is a limit to the amount of clearance that can be safely given, because the tooth must not be left so weak as to break under working conditions. . . .

"Examination of the files shows that these angles are extremely variable, *and it is certain that uniformly satisfactory results cannot be obtained unless correct angles are ascertained and maintained by means which will leave no scope for variation of judgment on the part of the workman.*"

(The italics are mine, and such significance is contained in the passage, that all file-makers ought to give their most earnest attention to it.)

The inclination of the overcut and upcut to the axis of the file has considerable influence on the efficiency of the tool, and in this respect the variations that exist, not only amongst files of different makes, but also amongst files by the same maker, are very great. The angles found on the files of one maker were as follows:—

TABLE II.

	Hand Smooth 12.	Hand Bastard 12.	Hand Smooth 14.	Hand Second Cut 16.	Half-round Bastard 14 (Flat Side only).	Square Bastard 14.	Cotter Bastard 12.
	deg.	deg.	deg.	deg.	deg.	deg.	deg. to axis.
Overcut ..	55	58	53	50	57	54	55
Upcut ..	73	73	67	70	74	70	75

These files were taken at random from a new batch, and illustrate the lack of uniformity which is to be found in almost any batch of commercial files.

It may be said that the inclination of the overcut fixes the position of the teeth in relation to each other, and that of the upcut fixes the angle at which the face of the tooth is presented to the work. The possible variation in the inclination of the overcut and the upcut to the axis of the file can be advantageously manipulated to produce files to cut particular kinds of metal. This is done in the case of files intended for use on brass and aluminium. Some results of varying the inclination of the upcut of files are to be seen in Figs. 17 and 18. If the upcut lies obliquely across the file, the filings will be similar to those shown in Fig. 18. If, however, the file tooth lies squarely across the file, then the filings have the shape of a volute spring, as shown in Fig. 26. But in either case, if the tooth has a large negative rake, the filings may be shapeless scraping like those in Fig. 17.

The number of teeth per inch, and the ratio between "overcut" and "upcut," are also factors in the efficiency of the file. Variations of both factors within fairly large limits may be made without the efficiency of the file suffering. With the upcut 19 teeth per inch on a 14-in. bastard cut file, variations in the overcut from 6 to 15 teeth per inch may be made without loss of cutting efficiency. Sufficient experiments, however, have not been made in the ratio variations to enable any standard to be accepted as the most satisfactory. Mr. Herbert is right when he says: "The ratio may prove to be one of the most important factors in file efficiency."

It is not intended to discuss the question of file-testing, but reference must be made to a point which always crops up whenever files are put under test; that is, the variation in the two sides of a file. Mr. Herbert says: "It has been suggested that the side first cut is injured during the cutting of the second side by contact with the block on which it rests. File-makers generally favour the explanation that the difference is due to a variation in the sharpness of the cutting chisel. It is said that a chisel will only cut five sides before it needs whetting. Perhaps it does not always get whetted as soon as it needs. If, therefore, a batch of files are all cut on one side, then turned over and cut on the second side, it must often happen that one side of a given file is cut with a newly whetted chisel and the other with a chisel that has become blunt."

The difference in the efficiency of the two sides of a file may arise, and does arise, from a combination of causes. These may be enumerated as follows: (1) Unequal blow of the chisel; (2) unequal filing of the overcut; (3) unequal whetting of chisel; (4) working too long with chisel; (5) the effect of the file bed; and (6) the variation in grinding; that is, the more or less complete removal of the decarburised envelope. Further more, the cutting edge of a file may not always lie in the same plane along the 6 inches of its length tested. There is no need to labour these points. They are to be expected more or less as greater or less care is exercised, but it is extremely doubtful that the two sides of a file chosen at random can be uniform under the present system of manufacture.

The extreme top of the teeth are sometimes bent backward, and very rarely may be accidentally bent forward even. All machine cutting, at any rate in this country, is executed from point to tang. After cutting a tooth the chisel is withdrawn from the impression made, and the traverse of the machine bed brings the blank forward to receive the next blow. If the chisel has not quite cleared the tooth before the bed moves forward, it catches on the tooth and bends the extreme tip of it backwards. Many of the newer forms of file-cutting machines are continuously fed forward by a screw instead of the older form of ratchet motion. When the machine bed is being fed forward continuously, the chisel must always be withdrawn against the face of the newly formed tooth, and the pressure between the two is the force with which the bed is being fed forward. On hard steels the tooth may resist this pressure without being bent backwards, but on soft steels the tips of the teeth would be very apt to become pushed backward

Fig. 20.—Teeth on ridges made too flat.

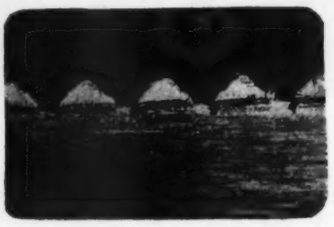


Fig. 21.—Weak pointed teeth. Overcut insufficiently filed.

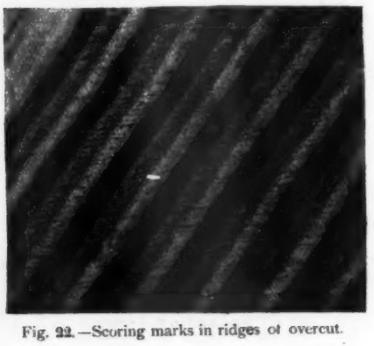


Fig. 22.—Scoring marks in ridges of overcut.

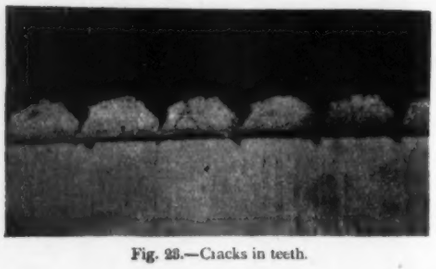


Fig. 23.—Cracks in teeth.

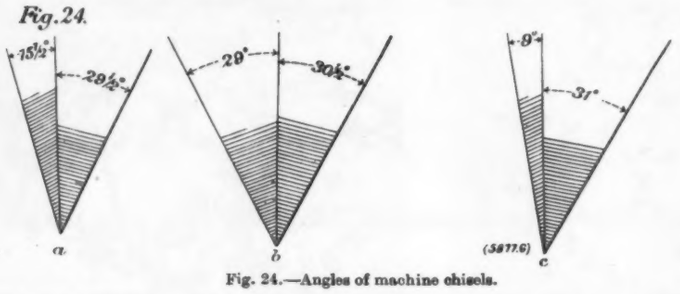


Fig. 24.—Angles of machine chisels.

without being able to spring again into normal shape. An occurrence of this kind increases the disadvantage of a negative rake which already exists, and may make a tooth hopelessly inefficient in spite of the main face having a positive rake. Only a small portion of the tooth of a file is worn away in actual use. The rake of this portion only determines its cutting efficiency, and unintentionally, in the way suggested, this may be made better or worse. Generally it becomes worse; the instances in which it is actually made better are very rare indeed, and amongst those rare instances it is by

Fig. 25.—File teeth with different clearance angles.

Fig. 26.—Volute-shaped filings.

Fig. 28.

a—Increased negative rake. *b*—Positive rake.

way of being a miracle that one should be chosen haphazard for testing purposes.

The following particulars refer to two files taken from the same batch. They were cut by the same man on the same machine with the same tools, and both were intended to have a rake of minus 5 deg. The efficiency of the two sides of the same file were fairly concordant, that is, both sides of file A did badly, and both sides of file B did well, when tested on the Herbert machines and bar. The curves produced by one side only are reproduced in Fig. 27. It was only after the tested files had been sectioned and photographed that their curious behaviour was explained. These photographs are reproduced in Fig. 28 and speak for themselves. The cutting edge of A has had the original negative rake increased, and that of B has been transformed into a tool with a very efficient positive rake.

The obvious means of avoiding the undesirable form of tooth in file A is to cut the teeth progressively from tang to point, on the same principle as adopted in the earliest of file-cutting machines by Leonardo da Vinci and Mathurin Jousse. By doing this the chisel will not pass up the face of the tooth and cause the tip to bend backwards. The best means of regularly producing teeth like those of file B remains a matter for investigation.

Hardening.—Many formulæ have been given during past centuries for preparations to be used in the hardening of files. That referred to under the heading of "Steel" as being in use in the tenth century is described by Theophilus Presbyter. It was in reality a sprinkling powder and was used for large files. The powder was prepared from ox horn by charring and pulverising together with salt. When the file was "white hot" this powder was sprinkled profusely all over it, and again heated in the charcoal fire blown by bellows. As soon as the powder had accomplished its work the file was quenched uniformly in water and then dried. "In this way," says Theophilus, "you will harden everything made of steel." In Sheffield, in the eighteenth century, files were hardened in a somewhat similar fashion. The files were smeared with ale grounds and then covered with powdered hoof and sea salt. After drying they were heated in a coke fire and then quenched. Ale grounds have been in use for a very long time; fine sharps, bran and flour, also have been used as a covering to protect the teeth, especially of fine cut files, as they were pushed backwards and forwards in the breeze fires.

In modern practice there are two methods of heating files for hardening: one by means of breeze fires, which we may call the old way; and the newer way by means of the lead bath. The lead may be heated by cokes or by gas. When first lead began to be used there was real difference of opinion as to the respective merits of the two methods. It was contended by those who used the hearth that the use of lead was responsible for a large proportion of soft files. This contention is still held to-day by some people. The main support of the argument seems to rest on the fact that in some cases where files have been soft after lead hardening they have been quite hard when re-hardened from the hearth, and this has been accepted as conclusive evidence that superiority lay with the hearth.

It does not seem very conclusive, however, when from repeated experience we know that such files as

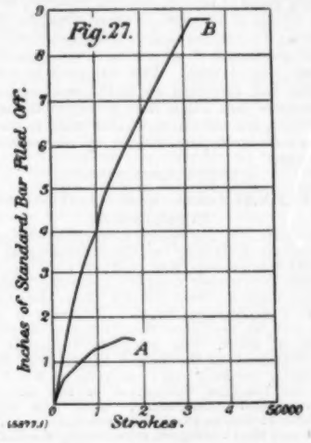


Fig. 27.

have been soft the first time hardening from lead, have been quite hard on a second and proper heating in the lead. If a file has been heated to the requisite temperature, and is not hard after quenching, the fault lies, not with the hardener, but must be sought in other directions, as we have indicated earlier. Such mixed lots of steel are used in the making of files, that it is very difficult for the hardener to work uniformly. Furthermore, he is working all day quenching in water the temperature of which is constantly rising. I have known the temperature rise so much that it was quite impossible to hold the hand in it. Again, if a workman is careless or "on the push" to get through a large amount of work, the probability is that some of the files will be quenched below hardening heat. These conditions may operate in both methods, and will explain how soft files may arise from hardening.

There can be little doubt that uniformity of heating is obtained more easily in the lead bath than in the hearth. Besides, being cleaner, the lead bath is more manageable. Fig. 29 shows the latest type of gas-fired lead bath in section to illustrate the internal arrangements. To get the best results it is advisable to use pyrometers either of the "Sentinel" or "Indicator" type. The uniformity of the temperature of the bath can be maintained very well by the use of sentinels if they are used in the following manner:

If it is desired to work at a heat between 750 deg. C. and 780 deg. C., procure two pieces of ordinary iron gas-piping with one closed end. The length should be about 10 in., or as long as desired for the bath. Stamp on each tube the melting point of the sentinels to be used. In the first case this will be 750 deg. C., and in the second 780 deg. C. Take two pieces of wire longer than the tubes and bend one end in the form of a hook. After placing the sentinels in their respective tubes, raise to melting point and insert the wires. On cooling, the salts will solidify and fasten the wires so that the tubes may be lifted by them. The tubes are now placed in the lead bath and the temperature raised sufficiently to melt the 750 deg. C. sentinels, but not those in the second tube, whose melting point is 780 deg. C. This can be easily ascertained by lifting the wire. In this way it is comparatively easy to maintain the heat desired, and to test the temperature of the bath in any part. A regular use of the sentinels or the indicator will considerably lessen the risks of quenching at a lower heat than is necessary to properly harden the files.

In conclusion, I plead for a definite and organised system of working in the manufacture of files—a system which will ensure a reliable quality of steel being always obtainable, and the production of blanks of uniform size and quality.

Scientific investigation throughout the whole of the processes is urgently needed, and makers ought to establish research rooms in their factories for that purpose. If it is considered undesirable that this should be done in each factory, then I would suggest that the Manufacturers' Association should agree to establish a central research laboratory well fitted with every convenience for conducting experiments under the charge of a well-qualified manager. The results obtained would then be available for all manufacturers, and we could reasonably look forward to a great improvement in the efficiency of the file and the methods of production. This would mean that the English file

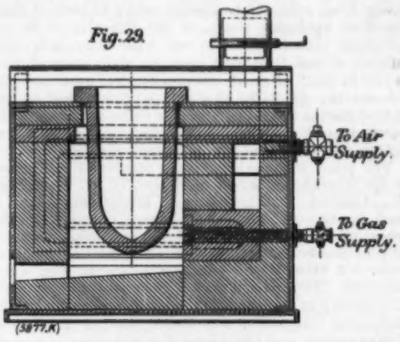


Fig. 29.—Cross-section of low-pressure gas and air lead bath furnace.

trade would receive a great stimulus—a thing we desire and hope to see.

I am indebted to Mr. Harry Brearley for the use of his experimental notes on the subject, and also for suggestions made in revising the paper. I should also like to draw attention here to the valuable and highly interesting memoir by Mr. Frémont * on "The File," to which members interested in the subject would do well to refer. My thanks are also due to Messrs. Richmond, of Warrington, who have kindly supplied me with drawings of gas-heated furnaces.

NON-METALLIC IMPURITIES IN STEEL.—In a paper on this subject read at a recent meeting in New York of the American Iron and Steel Institute, by Mr. H. D. Hibbard, the word "sonim" is used for the said impurities. It is an abbreviation for "solid non-metallic impurities." Other names which have been applied to sonims, or some of them, are oxidation products, occluded slag, entrained slag, non-metallic impurities, enclosures, entrained silicates, green markings, mechanically held impurities, and, more generally, inclusions, but, said the author, all fell short of the full requirements of a terse distinctive name. The word "insolubles" would have served fairly well, he added, had it been applied when the subject was new.

THE BRITISH DOMINIONS YEAR BOOK, 1919.—This year book, which makes its appearance rather late, contains a great deal of information on subjects of general interest in the form of separate articles by specialists. A review of the fourth year of the war, divided into sections relating respectively to naval, military and aeronautical matters, is included, and the food problem is dealt with in articles on the work of the Ministry of Food and the agricultural produce of this country. Other articles are devoted to such subjects as the Russian revolution, Japan, India, war finance, the Army Medical Service, inter-Imperial communication, and many other industrial, economic and political questions. A number of maps, diagrams and portraits of prominent men are also included. The book is published by the Eagle, Star and British Dominions Insurance Company, Limited, of British Dominions House, Royal Exchange Avenue, London, E.C. 3. Its price, bound in blue-cloth covered boards, is 1*s.*

BUSINESS WITH CHINA.—Commercial and industrial progress in China must naturally depend upon the solution of the constitutional and political troubles which keep that country in a state of ferment and unrest. In the meantime, however, we are glad to see, says *The London and China Telegraph*, that the Chinese Ministry of Agriculture and Commerce is preparing to take advantage of that long-looked-for good time when it comes. It has lately inaugurated several measures to this end, one of which is the proposed appointment of Commercial Attachés to Great Britain, France, Japan, and the United States. It is important that the Chinese Government and traders should be kept well informed as to the business conditions abroad with a view to the extension of Chinese trade with foreign countries. It is well known that China has many products which the world requires, and with the requisite development and energy large and profitable sales could be effected. It is to the interest of foreign traders that China should increase her export business, since by this means she would be enabled to make larger purchases of goods from them. The appointment of commercial attachés abroad should help to this end, and generally tend to promote trade relations between China and the principal countries with which she does business.

* "Études éxperimentales de Technologie Industrielle. par Ch. Frémont, Numero 49, *La Lime*, Paris, 1916.

A MODERN HEAT-TREATMENT PLANT.

IT can hardly be said that one section of a modern engineering factory is more important than another, and yet in view of the possibility of error and waste owing to insufficient knowledge, or unsuitable plant, one is tempted to suggest that the hardening or heat-treatment shop is frequently the basis of success or failure. The immense development in engineering work which the early days of the war called for found many firms seriously hampered owing to lack of plant for their hardening shops, or the difficulty of finding adequate skilled labour to run what they had. The subject of heat-treatment from the shop point of view is not in itself of great complexity, but even now the information generally available is not spread to the extent that is desirable, and it is to be hoped that the particulars of a modern installation we are able to give in this article may be of interest and use.

The plant with which we are concerned is situated at the Bournbrook works of Messrs. H. W. Ward and Co., Limited, at Lionel-street, Birmingham, and is used for the carburising, annealing, normalising and reheating of spindles, gear wheels and other parts of all-gear headstock lathes and other modern machine tools. A view of the plant is given in Fig. 1, on page 808. The heating part of the installation consists of a battery of reverberatory gas furnaces made by the Richmond Gas Stove and Meter Company, Limited, of Warrington, and 132, Queen Victoria-street, London, E.C. 4. For work of the kind done gas gives the accuracy and convenience of control which are so necessary for success. The furnaces are arranged in a row, and to facilitate additions an 8-in. gas main has been run round the shop with tees let in at regular intervals. The quenching arrangements can be partly seen in the foreground of the view. The bosch shown at the right-hand side is fed from a well with clean cold water, which is agitated to ensure thorough quenching when spindles and other heavy parts are being dealt with. The same water then flows through the jackets of the two oil tanks shown on the left and thence to the overflow. Lifting gear is fitted to permit the expeditious removal of any heavy part from any furnace to any quenching tank.

A cross-sectional view of one of the Richmond reverberatory furnaces is given in Fig. 2, on page 808. The gas supply is carried to the furnace by the main header A. The position of this header at the sides of the furnaces can also clearly be seen in Fig. 1. From the headers, a series of burners B tap off, each being fitted with a primary air valve C and the mixture of gas and air is carried to the furnace charger by the burner tube as is clearly shown in Fig. 2. Secondary air is introduced at D and carried along the furnace bottom in close proximity to the waste gases and thus preheated. Combustion takes place over the furnace arch and the gases then pass under the furnace floor and out to the chimney, as will be clear from the figure. By this method a heavy floor can be fitted, which is not the case with an underfired furnace, and as combustion takes place in the furnace chamber itself a high degree of efficiency is obtained. The chamber of each furnace is 5 ft. 3 in. deep by 3 ft. wide by 1 ft. 6 in. high. Each furnace, as shown in Fig. 1, is fitted with a heavy foreplate 24 in. wide, which permits the door of the furnace to be closed immediately a pot is withdrawn, instead of the door having to remain open until the pot can be lifted away. This saves gas by conserving the furnace heat, besides protecting the operator from unpleasant radiant heat. A further point in connection with the installation is that parts of the shop roof can be moved in sections so that dust, steam and smoke from the quenching tanks can be dissipated into the air.

As has already been said, the plant is mainly used for the heat-treatment of machine tool parts. Large quantities of gear wheels are dealt with and demand great care in order to avoid distortion. The method of procedure is to turn, bore, partly castellate and partly cut the gears, and then to anneal them at 750 deg. C. for 6 hours to 8 hours packed in cast-iron swarf. The gears are cooled out in the pots. The finishing broaches are then put through to complete the castellation, and the teeth are finished on the gear-cutting and tooth-rounding machines. Carburising is then carried out at 900 deg. C., 4 hours' soaking being given and the gears being allowed to cool down in the pots. Each gear is then reheated, first at 850 deg. C. and quenched in oil to refine the core, and again at 750 deg. C. and quenched in oil again to harden the case. This method has been found to reduce the number of rejects to practically nil, and 14-in. and even 18-in. spur wheels are successfully treated.

When dealing with spindles, the forging is usually turned on the diameters and faces which are required to be hard, the usual grinding allowance being left on. The spindle is then carburised at 900 deg. C. for 6 hours and cooled out in the box, or tube. Each spindle is carburised in a separate tube, and great care has to be exercised in packing the tubes in order to avoid distortion and the consequent necessity for straightening. The rest of the machining is then done, so that all parts required to be soft for screw-cutting, key-waying, &c., are sure to be free from carbon from the carburising operation. The spindle is then reheated to 850 deg. C. and quenched in water in a vertical position and again reheated at 750 deg. C. and again quenched in water. The many other hardened parts which are used in modern machine-tool production are treated in the same general way; examples are ball-thrust races, indexing parts of turrets, springs, plungers, worms and worm wheels of all types of speed-changing gears and clutches. It is interesting to note that in order to get correct treatment of all parts, a test-piece is placed in every box of work. This test-piece is withdrawn, reheated and quenched under the same conditions as the machine part. It is then passed to the inspection department for Brinell and other tests to ensure that the manufactured part will be up to specification in every way.

INTERNATIONAL ELECTROTECHNICAL COMMISSION.

THE meeting of the Special Committee on the Rating of Electrical Machinery of the International Electrotechnical Commission was held in Paris last month. Delegates were present from the National Committees of Belgium, Canada, Great Britain, Italy and the United States. The Canadian delegate, Professor A Gill, was taken over by aeroplane from London to attend the meeting in Paris. The delegates appointed by the Main Committee of the British Engineering Standards Association, the Sectional Committee of which is, *ipso facto*, the National Committee of the International Electrotechnical Commission, were the following: Mr. Roger T. Smith, president-elect, I.E.E.; Mr. A. R. Everest and Mr. C. Rodgers, representing the B.E.A.M.A. on the British National Committee. The delegates were welcomed by the president of the Commission, M. Maurice Leblanc, at a lunch offered by the French Committee. The technical meetings lasted three days, and a number of important points were discussed.

Certain difficulties which had arisen, more especially between the American, British and French National Committees, due largely to the war conditions, but which had occasioned some feelings of uneasiness on the part of the French Committee, were gone into in detail, and at the conclusion of the meetings, M. Paul Boucherot, who had presided over the meetings, expressed on behalf of his French colleagues his complete satisfaction with the explanations offered.

The French Committee entertained the delegates at a banquet at the Hotel d'Orsay, and Dr. C. O. Mailloux and the Americans subsequently offered the delegates a banquet at the Hotel Maurice. An opportunity was taken of the presence of a number of the founders of the International Electrotechnical Commission to discuss matters of organisation and also the attitude which should be taken up in regard to the enemy countries. Moreover, in order to honour the founder of the Commission, Colonel R. E. Crompton, C.B., it was proposed that the next plenary meeting of the Commission shall be held in London in October next. This proposal is now before the various National Committees, a number of whom have already signified their agreement therewith. It may be expected, therefore, that a very representative meeting of the International Electrotechnical Commission will take place in London towards the end of October.

It is interesting to note that the last meeting of the Commission held in London was in 1908, but since that date the meetings, of which several have been held annually, except during the war, have all been held abroad, so that the gathering in October will afford an opportunity of giving a very special welcome to prominent electrical engineers from other countries who come to London on that occasion.

SWEDISH INDUSTRIES FAIR.—We are informed by the Royal Swedish Consulate General in London that a Swedish Industries Fair will be held in Gothenburg, from July 7 to 13. An Industries Fair was held in Sweden for the first time in July, 1918, and in spite of adverse conditions in the industrial market and many other difficulties the plan met with great success; 544 exhibitors had a turnover of 22,000,000 kronor; the Fair was visited by 42,000 people. The Fair this year will be held under much more favourable conditions. The exhibition is to include several groups of articles exported to the United Kingdom.

THE SURVEYORS' INSTITUTION: SPECIAL DIPLOMA EXAMINATIONS.—The holding, by the Surveyors' Institution, of the Special Diploma Examinations has been resumed, and names of intending candidates should be sent in to the secretary before the end of the current year for the examinations to be held in June, 1920. It has been decided to offer a special diploma in rating, as well as in forestry, sanitary science, and advanced land surveying. The Rating Surveyors' Association have kindly offered a prize of 10 guineas for the successful candidate at the head of the list in rating, and the Daniel Watney prizes of 10*l.* and 5*l.* will, as usual, be awarded in forestry. The council desire to impress upon members the advantage of making themselves specialists upon subjects connected with their profession, and opportunity is offered by the Special Diploma Examinations for this purpose. They hope that the revival of the examinations after the war will result in a good entry of candidates. Particulars as to syllabus, &c., may be obtained from the secretary.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Despite high prices, an active trade is passing in pig-iron. There are indications that the quantity available is barely sufficient to cover manufacturing needs. Open market sales are restricted owing to the diminished tonnage on offer. Buyers are more numerous than sellers, and there is no easement, or immediate prospect of easement, in values. By far the heaviest demand is for basic pig-iron. North Lincolnshire makers have laid themselves out specially to meet steelmakers' increased requirements in this respect. Revised quotations (delivered in Sheffield) are as follows: East Coast hematites, 9*l.* 10*s.*; West Coast hematites, 9*l.* 15*s.*; Lincolnshire basic, 8*l.* 5*s.* to 8*l.* 10*s.*; foundry, 7*l.* 12*s.* to 7*l.* 15*s.*; forge, 7*l.* 10*s.*; Derbyshire basic, 8*l.* 7*s.* 6*d.*; foundry, 7*l.* 10*s.*; forge, 7*l.* 5*s.* Complaints of delays in deliveries of finished iron are freely circulated. Bar mills are up against difficulties of output which the introduction of shorter working hours has failed to remedy, and there appears to be little doubt that local consumers will fall back upon Belgian material, which they used freely before the war, as soon as deliveries can be obtained. Belgian bars are promised in August or September at prices favourably comparing with local makes, which are offered at 20*l.* 10*s.* Steel billet makers report a steady business. Anxiety is felt with regard to American competition, but many of the rumours and reports afloat are discounted as being exaggerated. Bessemer acid are quoted at 16*l.* 12*s.* 6*d.*, Siemens' acid 17*l.* 2*s.* 6*d.*, hard basic 15*l.*, and soft basic 14*l.* 10*s.* Most of the heavy engineering branches are well employed, with fair prospects. There appears to be no diminution in the call for shipbuilding steel, and for tools, either for export or home consumption. In railway material, export business is on a larger and more satisfactory scale than home requirements. India is again becoming a strong market, and there is prospect of further substantial orders following those already booked. British buyers of axles, tyres and springs, however, are disposed to favour a cautious policy. Immediate needs having been met, business is inclined to languish. No improvement can be reported in electric steel or in special steels. Trade in the latter has fallen to a low ebb, and is likely to remain there until the large stocks remaining at works from war activity are consumed. In the lighter trades the gross volume of business is well above the average, and in some branches approaches "boom" conditions. Agricultural implements and tools are in brisk demand on export account. Substantial orders have this week been placed from Madrid, Natal, Hong Kong, Melbourne and Quebec. An active trade is passing, in fact, in all kinds of small tools, excepting those of special quality steel. Some of the best orders recently received for files, saws, butchers' knives, nippers, sickles and scythes, are from Africa and Australia. New York is a good customer. The scrap market is quiet. Manufacturers are asking prices for the best wrought scrap 11*l.* to 11*l.* 10*s.* in advance of those offered.

South Yorkshire Coal Trade.—In the house coal section the demand for current requirements has shrivelled with the continuance of warm weather. Merchants, however, are buying all they can get hold of for stocking purposes, and the output at the pits is regularly absorbed. Best steam hards maintain their recent position, and are strongly held. House requirements are well up to the average, while export demands show a healthy expansion. Cobbles and nuts continue a good market. Contract requirements are large, and leave little for open market disposal. The position with regard to slacks still shows some little weakness, especially in inferior qualities. Steel cokes are moderately strong, and blast-furnace and foundry coke are in good request at maximum prices. Quotations:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Actual business passing in Cleveland pig-iron is not very extensive just now, but a very firm feeling prevails, and there are still considerable inquiries on forward account. The only iron available for prompt sale just now is forge, which is comparatively plentiful, and is offered rather freely. Transactions recorded in the better qualities are almost entirely confined to home sales over the third quarter, which is as far ahead as most makers care to commit themselves, notwithstanding efforts of buyers to enter into contracts for delivery to the end of the year. Foreign trade is practically idle. Export licences are unobtainable, and whilst permits, issued before the ban on shipments abroad was imposed, are being made use of to a small extent, holders of such licences report that so great is the pressure for supply to meet home requirements that purchasing for export is almost impossible. For home consumption, both No. 3 and No. 4 foundry stand at 160*s.*, No. 4 forge is 158*s.* and No. 1 is 164*s.* Export prices are 5*s.* above these quotations.

Hematite Iron.—There is little doing in East Coast hematite iron in view of anticipated rise in price to cover increased cost of production. Prompt purchasing is almost impossible, but some of the iron bought by merchants, a little while ago for export and which cannot now be shipped, may, in the near future, be offered for sale to home customers. As yet, market rates still stand nominally at 190*s.* for mixed Nos. and

192*s.* 6*d.* for No. 1 for home purposes, and 195*s.* for mixed Nos. and 197*s.* 6*d.* for No. 1 for export.

Output of Pig-Iron.—The quantity of pig-iron now being produced varies very little, but the quality of the make is irregular. There are now 67 blast furnaces in operation in this district, 32 of which are producing Cleveland pig-iron, 22 are making hematite, and 13 are manufacturing other kinds of iron.

Foreign Ore.—Value of foreign ore continues to advance, and consumers though reluctant to follow the rather rapid rise, are compelled to come into the market to purchase, as in some cases the steadily dwindling stocks have now been reduced to a low level. Best rubio ore is quoted up to 59*s.* c.i.f. Tees, and freights Bilbao–Middlesbrough, are now fully 30*s.* It is reported that there is a renewal of the directing of unladen tonnage at French western ports to Spain for ore instead of journeying home in ballast.

Coke.—Coke keeps steady and firm with considerable business passing, an ample supply meeting the large needs. Medium blast-furnace kind is 39*s.* at the ovens, and quality low in phosphorus is 41*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—In finished iron and steel American competition, increasing cost of production, and labour troubles, are embarrassing features. The engineers' strike for a 44-hours' week has already necessitated the closing down of some of the steel mills, and unless a speedy settlement is arrived at the stoppage of work will be seriously extended. Steel plates and angles have been advanced 15*s.* per ton and joists 10*s.* per ton. To home customers, common iron bars are 20*l.* 10*s.*; marked bars, 23*l.*; strip iron, 21*l.* 15*s.*; steel ship, bridge and tank plates, 17*l.* 15*s.*; steel ship angles, 17*l.* 5*s.*; steel joists, 17*l.*; and galvanised sheets, 27*l.* 10*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—There is a pronounced scarcity of coals and the demand is considerably in excess of available supplies. At the same time there is ample shipping in the various docks, and the railway and loading facilities are not adequate to cope with outputs notwithstanding that production ever since the introduction of the Sankey award has been substantially below normal. Many locomotives are awaiting repairs, and a number actually in use require overhauling. In consequence of this lack of engine power considerable congestion prevails on the railways, and in consequence empty trucks are not returned to collieries as quickly as is desired. Many of the vessels now in docks arrived before the holidays, and have since been waiting for cargoes. To-day there are over 640 vessels in the Cardiff, Penarth, Barry, Newport, Swansea and Port Talbot docks waiting to load coal cargoes. Here and there it is still possible, however, for buyers with boats actually under the tips to secure isolated parcels at prices considerably below current quotations, as some collieries, though fully stemmed on paper, find it difficult to keep going on account of a scarcity of wagons, and are therefore ready to make sacrifices in order to obtain a clearance of trucks. Generally, however, prices are very firm, but irregular, and for this month's shipment collieries in the majority of cases are fully sold. The demand for France and Italy is decidedly in excess of available supplies and sellers are asking up to 55*s.* for best Admiralty large and from 35*s.* to 40*s.* for small steams, according to quality. Business is quiet on the basis of from 50*s.* to 52*s.* 6*d.* for Admiralty large and up to 40*s.* for smalls and in isolated instances these prices have been exceeded. The inquiry for Spain is not too active, and Spanish buyers display a waiting attitude, it being reported that they can secure American coals cheaper than Welsh. Difficulty in securing releases also checks business. Sellers demand up to 60*s.* for Admiralty large and 45*s.* for best small steams, though business has been concluded at from 2*s.* 6*d.* to 5*s.* below these prices. Scandinavian, Dutch and Greek business is inactive, with sellers ready to accept the minimum price of 75*s.* for best Admiralty large and up to 45*s.* for smalls.

Newport.—Firm conditions pervade the Monmouthshire section and supplies are inadequate to meet the demand. For allied countries good Monmouthshire large coals range from 47*s.* 6*d.* to 52*s.* 6*d.*, and smalls from 35*s.* to 40*s.*, while for Spain and South America from 2*s.* 6*d.* to 5*s.* above these figures are asked. Exporters have plenty of tonnage to meet their requirements, but shipment is checked by congestion on the railways and a lack of tipping facilities.

Big Contracts Placed.—The Paris–Orleans Railways have placed contracts for 1,250,000 tons of various classes of Cardiff and Newport large and small coals for delivery over the next twelve months. The prices are stated to range from 2*s.* 6*d.* above A schedule for the inferior smalls to a premium of from 10*s.* to 12*s.* 6*d.* for the better class large steams. The French Marine have also placed orders for over 100,000 tons of Admiralty large coals, delivery July–August, at between 47*s.* 6*d.* and 50*s.* There is an active inquiry for delivery over periods, but collieries generally are reluctant to commit themselves in view of the uncertainty of the position in regard to outputs, and the effects of a 7-hour day, which comes into operation in July.

Proposal to Abolish Peace Work.—An important item on the agenda at the Miners' Conference was a proposal to abolish piece work for all grades at collieries. In one case it was suggested that a ballot of the whole of the coalfield should be taken on the question of the establishment of a day wage rate. After discussion it was eventually decided that piece-work rates should be abolished, and it was understood that further steps will be taken to give effect to this decision.

Miners and Income-Tax.—Recently a delegate conference of the South Wales Miners' Federation advised miners to adopt a passive resistance to the demands for income-tax, and as a consequence individual workmen have carried out the instruction of the federation. This has led to the arrest of these resisters, and in consequence a number of colliery stoppages have taken place, the men demanding the release of the arrested workmen. Yesterday 4,000 miners employed at the Glamorgan Collieries, Llwynypia, were idle, but eventually resumed work because the amounts claimed were in respect of the September, 1918, quarter. Similar occurrences have been responsible for temporary idleness at other collieries, and this is having a serious effect on outputs.

Strike of Clerical Staffs.—The clerical staff of Cory Brothers, Cardiff, colliery owners and shipowners, have come out on strike for increased wages and recognition of the National Union of Clerks, to which most the strikers belong. So far the firm has refused to recognise the men's union, and complain that they should have been approached direct by the clerks if they had any complaint to make. The clerical staffs at Cory Brothers' collieries have given the firm six days' notice that unless a settlement is reached by the end of the week they too will cease work, and there is a possibility of the company's collieries being rendered idle. Yesterday the trouble further developed for the clerks at some of the company's collieries ceased work and also received the co-operation of the weighers, with the result that some of the pits were rendered idle. In the evening the weighmen decided to return to work, and the night shift restarted. The clerks, however, remained idle. Apparently no effort has yet been made by the company to open negotiations with the National Union of Clerks, and it is feared that unless an early settlement is reached the trouble will spread to other collieries.

Capsized Vessel Raised.—The steamer Colorado, which turned turtle in the East Docks, Cardiff, in February last, and has since been lying partly submerged, was raised on Sunday last by the aid of seven locomotives and two French Navy tugs. Chain cables were placed round the vessel, and to these were attached wire cables working through pulley blocks. These were hitched to six engines, working in pairs, and were used to pull the vessel upright. The two tugs and one locomotive, which were working on the opposite side of the docks, were employed in pulling the vessel out from the quay wall so that she could be got on an even keel. The actual raising of the vessel took 6 hours, and was carried out by a section of the French Navy. The vessel is owned by the French Government.

Tin Plate Workers' Wages and Hours.—The Joint Tin Plate Industrial Council has agreed that for the three months ending September 27 there shall be an all-round increase of 12½ per cent., but that the demand made on behalf of those who had not participated in the engineers' award for an additional 12½ per cent. on top of the 12½ per cent. conceded generally would be referred to arbitration. In connection with the demand of the men for a 6-hour shift it was agreed that no extra mill shall be started in individual works until all mills now working in these works were on a 6-hour shift, also that no mills should be stopped in order to change from 8 hours to 6 hours. Representatives of the employers and men are going to the United States to consider the conditions in force there, and will report to the trade on their return.

Syndicalist Miners Defeated.—At the annual conference of the South Wales Miners' Federation at Cardiff yesterday an attempt was made to oust the present leaders from their offices. The effort, however, proved abortive, for by overwhelming majorities the Right Hon. W. Brace, M.P., was re-elected president, Mr. James Winstone, J.P., vice-president, Mr. Alfred Onions, M.P., treasurer, and Mr. Tom Richards, M.P., general secretary, for the ensuing year.

HEAT-TREATMENT OF STEEL.—In recent months, says *The Iron Age*, an organisation has been born which has already assumed national scope. From the mother organisation in Chicago, the American Steel Treaters' Society has spread, until there are local chapters in New York, Philadelphia and half a dozen other cities. It has already set on foot a broad programme. A national convention and exhibition are announced for Chicago late in September. A journal has been published for several months. A national research laboratory will probably be set up to further impartial research for the benefit of members and to advance the interests of the society.

PAPER-MARKING WITH METALLIC STYLES.—In a communication brought before the Sydney branch of the Society of Chemical Industry last November, W. J. Kirchner, B.Sc., described experiments made on the effect of metal styles on paper previously coated with solutions of glue in water, containing various metallic oxides, and then dried. Most of the oxides tried (alkaline earths, aluminium, zinc, tin, arsenic, antimony), and most of the styles, of copper, brass, tin, zinc, lead, silver, gold, platinum, magnesium, aluminium, gave suitable marks; of the common oxides only zinc hydroxide failed in this respect, being faintly marked only by the softer metals; the oxides of antimony and arsenic did not answer with certain styles (copper, brass, zinc, platinum, iron). The solutions of glue could be replaced by gum arabic but solutions of glue or of gum arabic alone did not suffice to call forth markings on paper when written on with metallic styles. The subject appears to deserve further study.

NOTICES OF MEETINGS.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, June 30 (instead of Thursday, June 26), at 6 p.m., at the Institution of Civil Engineers, Westminster, Captain L. B. Turner's paper on "The Oscillatory Valve Relay; a Thermionic Device," will be read and discussed.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, June 24, at 8.15 p.m., at the Royal Society of Arts (John-street, Adelphi). Annual meeting, when a discussion on "Street Lighting Reconstruction Problems" will be opened by Mr. L. Gaster. Members' formal business at 8 p.m.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—During the past few weeks the conditions in the Scotch steel trade have varied very little and each week is very like the previous one. The plate mills are running full and turning out a large tonnage, but despite this, some difficulty is experienced in meeting the home demand, which is very pressing. Order books are well filled and sellers are not inclined to commit themselves ahead owing to the uncertainty of prices. These are continuing very strong and will come up for reconsideration shortly, but with pig-iron tending upwards there seems every prospect of steel material doing likewise. There is no run on sections just now, but quite a considerable business has recently gone through for black sheets, particularly of heavy gauge, and mills are being kept going steadily. The galvanised sheet trade is rather dull, even on home account. Inquiries for export are quite good, but there is very little to offer, with the result that when the home market is supplied only small lots remain.

Malleable Iron Trade.—No change falls to be reported in the malleable iron trade of the West of Scotland, and active conditions are still general. The output, which is good, is quickly cleared off, mostly against home orders, and comparatively little is available for export. Prices are firm.

Scotch Pig-Iron.—In the Scotch pig-iron trade little or no change has taken place, and buyers keep pressing makers to accept fresh orders, but the latter are very reluctant to accept much in the way of forward bookings owing to the present state of the market. Both forge and foundry iron are scarce and the latter has advanced in price while all other qualities are also on the up grade. The supply of hematite is still a matter of no little concern to the steel makers, and an advance in price is more than likely very soon. The effect of this will cause an all-round raising of prices, and the whole trade position will then require to be considered very carefully if we are to compete in the foreign market. There is a distinct scarcity of tonnage, and the freight demanded on imported ore to Glasgow is very high—much higher than to some other ports. If some saving could be secured in that direction there would be reason to expect a check to the continued raising of prices, but otherwise the producers have no other course to follow. The export trade naturally continues very small, and for the week ending last Saturday, the 14th inst., the amount shipped from Glasgow Harbour was 445 tons, all foreign, against 218 tons foreign, and 57 tons coastwise, for the corresponding week of last year.

Shipbuilding.—A fair amount of activity is general in the various shipyards on the Clyde, and quite a good output has already been made this month. In contrast to May, merchant tonnage will be found to have taken a better place in the month's totals. There is a great lot of repair work on hand, and this is rather a costly item to owners because of the high rates demanded by labour and the heavy cost of all materials. Not much in the way of fresh booking has been reported, but several satisfactory contracts are understood to have been fixed up recently.

Scotch Coal Trade.—The demand for Scotch coal for industrial purposes, although on a large scale, is not quite so pressing this week, while for domestic use it has fallen very considerably. Railway companies continue to buy steadily and gas undertakings are ever ready to lay in stock and keep pressing for regular deliveries. A fair amount of shipping is being carried through, but this branch of the trade cannot improve until the output is greatly increased. The current prices are as follow:—Navigation steam, 54*s.* 6*d.* to 55*s.* per ton; Lanarkshire Hartley, 50*s.* per ton; Lanarkshire Ell, 53*s.* 6*d.*; and Lanarkshire splint, 55*s.* per ton—all net, f.o.b. Glasgow.

COAL, GAS AND ELECTRICITY ORDER.—The Controller of Coal Mines regrets to announce that it is found necessary to continue the rationing of coal, gas and electricity for household fuel and lighting for a further period. It is, however, proposed to modify the present order to the extent that consumers of less than 5 ton of coal in the year, 12,500 cub. ft. of gas in any quarter, 400 B.T.U. of electricity in any quarter, will not be subject to assessment. They must, however, be registered with their coal merchants, for the supply of coal. A revised Order which will take effect from July 1 next, will be issued during the present month. Economy in the consumption of coal still remains vital to the national interests. If the output of coal in the near future will allow a relaxation of these restrictions, the Local Fuel Overseer will be authorised from time to time to receive applications for such increased allowances as any increase in the supplies of coal may justify.

HEAT TREATMENT PLANT; WORKS OF MESSRS. H. W. WARD AND CO., LTD.

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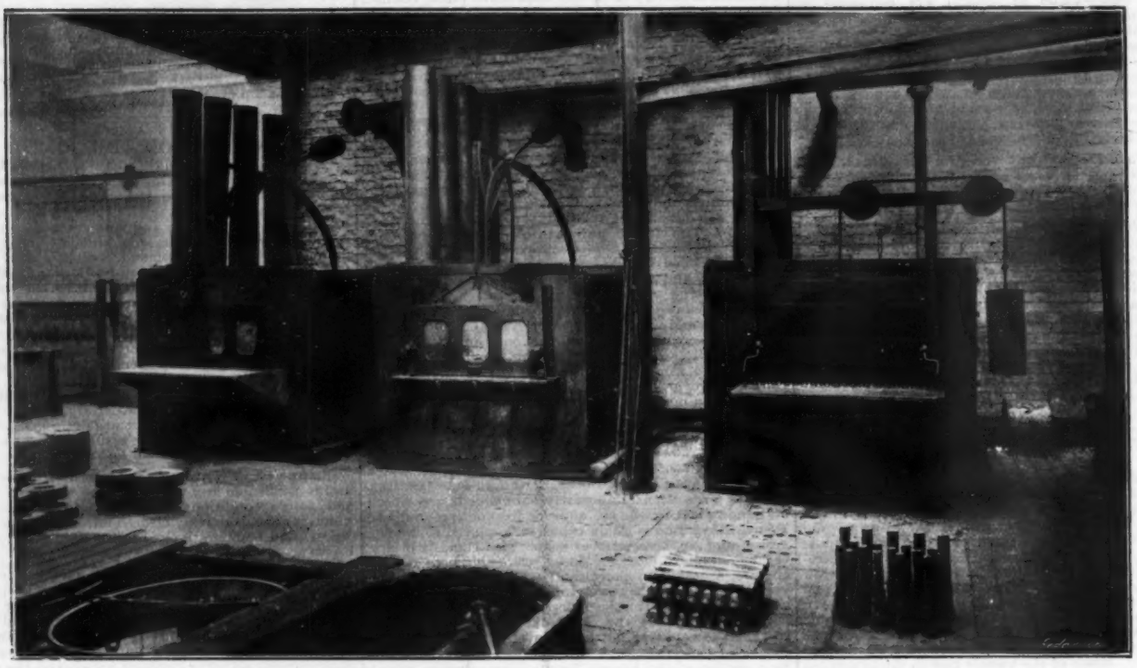

FIG. 1. GENERAL VIEW OF HEAT TREATMENT PLANT.

THE JAMES WATT CENTENARY.—In connection with the James Watt Centenary, which is being celebrated this year, the committee dealing with the matter is anxious to make the exhibition of Watt, Boulton and Murdock relics as comprehensive as possible. For the purposes of exhibition, the Birmingham City authorities are loaning rooms in the council house, and all proper care will be taken of the exhibits. It is also desired to prepare as complete a list as possible of relics, so that their existence may be recorded. The committee having the matter in hand earnestly request those having relics to loan them, and those knowing of relics or other matters of interest associated with the names of Watt, Boulton or Murdock, to communicate with the Secretary (Exhibits), James Watt Centenary Committee, Chamber of Commerce Building, New-street, Birmingham.

THE RÖNTGEN SOCIETY: X-RAY PHOTOGRAPHY.—At the annual meeting of the Röntgen Society, held recently in the rooms of the Royal Society of Arts, Mr. Sidney Russ, D.Sc., of the Cancer Research Laboratory, Middlesex Hospital, formerly one of the honorary secretaries of the Society, was elected president in succession to Dr. C. B. Batten. After the formal proceedings, Mr. N. E. Luboshey made a further communication on the "Photographic Action of X-Rays," on which he had spoken on the same occasion last year. Mr. Luboshey again accentuated that the developer should be used weak, and he accentuated the necessity of working under standard conditions. In that case more reliability could be placed on securing comparable photographic effects than by adjusting the spark gap or current and by using soft and hard rays or altering the distance. What Mr. Luboshey said on faulty manipulation of plates and films had particular reference to the hurry which had been unavoidable often during the war in the operating rooms, when medical men, anxious to see the results of an X-ray examination, had not rarely spoilt their imperfectly fixed plates by exposing them to the action of air and light. But there is a good deal of mismanipulation generally, and Mr. Luboshey may be right in attributing 90 per cent. of what is put down to "secondary radiations" simply to unsuccessful manipulation and developing. Plates should be developed, fixed and washed in vertical cells rather than in horizontal baths, with the aid of frames to treat several films simultaneously. When horizontal baths must be used, the film should be drawn backward and forward, the operator taking hold of one end and bringing the two sides alternately in contact with the bath. The lecturer had no fancy for hydroquinone, although he had learned to use it; but he did not recommend hydroquinone and metol. The trouble with hydroquinone was that a slight difference of temperature made a great difference. Pyrogallic acid was not, as a rule, used for radiograph developing, but it had the advantage that it did not favour fogging. Fogging was, on the whole, not to be feared unless the plate had been under-exposed. In order to shorten the exposure, which was a vital question for the patient, the plates and double-coated films should be placed between intensifying screens. Excellent radiographs obtained with exposures of only 3 seconds were exhibited. The use of considerable amounts of bromide retarders was not advisable, in the interests of good development; in the place of bromide mixtures of old and fresh developers might be used, but only in cases when one knew what one was dealing with. Dr. Batten remarked that he had found Mr. Luboshey's recommendation of weak developers very useful; he also agreed with the suggestions made as to showing good radiographs both of the tissue and bones.

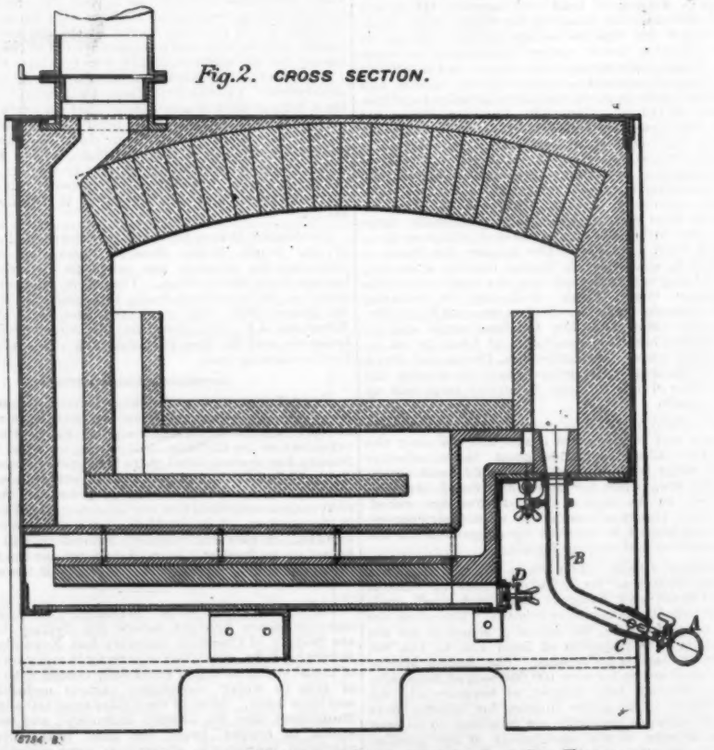

FIG. 2. SECTION OF "RICHMOND" REVERBERATORY GAS FURNACE.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication, and certainly not later than Monday morning.

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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 807.

ENGINEERING.

FRIDAY, JUNE 20, 1919.

GAS CYLINDERS.

THE war has produced such a wealth of official counsellors in all technical matters that industry is not likely to suffer from a lack of technical advisers for many years to come. The danger is that these officials or ex-officials with only a war-time experience to guide them, may tamper with sound and well-established trade regulations which are the outcome of prolonged and practical experience. The present position with regard to high-pressure gas cylinders is, we consider, a case in point.

The trade in compressed gases before the war was conducted in this country with a remarkable immunity from accident, partly because it was in responsible and experienced hands, but mainly because competition in the weight of gas cylinders and the composition of the material employed in their construction, was virtually impossible. That dangerous form of competition was fortunately stifled in the early days of the industry by the appointment in 1895 of a Home Office Committee to report on the "Precautions required to ensure the safety of cylinders of compressed gases." Although no legislation followed on the committee's report, their recommendations have not only been adopted as trade regulations, but public rail, road and water carriers have embodied them in their by-laws relating to the transport of gas cylinders. Thus, without fettering the industry by direct Government control and inspection of cylinders, uniformity in their construction and consequent public safety have been effectively secured (1) by the issue of an official specification which the by-laws of public carriers have rendered obligatory and (2) by not relieving the gas compresser of any of his legitimate responsibility.

For many years before the war only seamless cylinders were employed for compressed gases, and uniformity in their weight was secured under the official specification contained in the report which limited the working stress in cylinder walls to 8 tons per square inch. This condition has always been regarded by the trade as reasonable. The industry has developed with a rapidity which compares favourably with that of other countries, and there is no serious demand for lighter cylinders. The official specification of the metal to be employed in the construction of cylinders, requires iron to be not less than 99 per cent. and carbon not more than 0·25 per cent. This has ensured a good and ductile steel, which has been employed in the manufacture of seamless cylinders for many years with absolute reliability. These conditions are perhaps not quite so easy of fulfilment to-day as formerly, and cylinder makers would prefer to employ steel of a slightly higher carbon content. A maximum limit of 0·35 per cent. instead of 0·25 per cent. has been suggested, and this might be accepted as a reasonable and advantageous modification, provided the other conditions of the official specification remained unchanged, and this increase in carbon was not used as an argument for reducing the weight of cylinders.

In point of fact, some reduction in weight will be effected automatically by increasing the carbon content in the metal, because this will raise not only the ultimate tenacity of the steel, but also the yield-point and thus allow more margin between the stress due to the hydraulic test and the latter than exists at present. The official hydraulic test for cylinders charged with gas to the trade pressure of 120 atmospheres, is 224 atmospheres, which means that cylinders proportioned for a working stress in the metal of 8 tons per square inch, are subjected under the test pressure to a stress in the metal of 15 tons per square inch. With steel containing a maximum of only 0·25 per cent. of carbon this stress is liable to come so near to the yield-point of the metal, that in order to avoid any risk of permanent stretch, the tendency of makers has been to somewhat exceed the required thickness of walls. It would, therefore, be possible by increasing the carbon content to 0·35 per cent. to reduce the weight of cylinders by about 10 per cent., without altering any other conditions of the official recommendations and without any appreciable sacrifice of ductility. The carbon limit will even then be lower than it is customary to employ in other countries and considerably less than is sometimes advocated here by persons who are not thoroughly conversant with the risks to which this cylinder traffic is exposed.

High-pressure seamless cylinders originated in this country, and it was here alone that the requisite precautions were taken from the outset to avert the danger of competition in the weight of cylinders, and to prevent the use of hard and unreliable metal in their manufacture. Other countries have been slow to adopt similar precautions with the result that, whilst cylinder stocks here were accumulating year by year on a trustworthy standard, they were being produced everywhere else under conditions of keen competition in weight. This led to the sacrifice of ductility in favour of a metal capable of withstanding a high working stress. When in each country in turn it became obvious with the development of the oxygen industry that more stringent regulations were required, the large stocks of light-weight cylinders which had accumulated, had to be considered, and that fact undoubtedly coloured official regulations. Competition in the weight of cylinders has certainly been checked and the tendency in recent years—particularly in Germany before the war—has been towards lower working stresses in the metal, but the fact remains that most cylinders circulating in Europe and in America, are of harder metal and thinner section than the British standard, and that whilst cylinder accidents are almost unknown here, such is by no means the experience elsewhere. For ordinary commercial purposes too much importance can be attached to the question of lightness. Experience shows that when the dangerous element of competition in that respect is removed and all cylinder suppliers are put on the same footing, then the question of weight soon ceases to be regarded as a factor of prime importance.

Having indicated generally the pre-war position with regard to high-pressure cylinders, and the only modification in their existing regulations which the British industry seriously desires, we now propose to show how a relatively simple matter has been needlessly complicated, and a well-regulated trade disturbed by many theoretical advisers and by lack of co-ordination amongst Government departments during the war. Immediately before the war the Admiralty was purchasing oxygen cylinders to a very exacting specification of its own, which not only complied with all the recommendations of the Home Office Committee, but went even further and provided for heavier cylinders than those employed by the trade.

On the outbreak of war, the Admiralty found itself virtually without hydrogen cylinders and had to rely at first almost exclusively on private enterprise for both cylinders and gas. The Royal Naval Air Service was then established and large sums voted for the immediate erection of hydrogen plants and the production of cylinders. Whether the vast expenditure on these plants and cylinders has been justified by results will no doubt some day be the subject of investigation. One deplorable effect, at any rate, of the Admiralty's enormous purchase of hydrogen cylinders throughout the war, has been to practically stop the production of seamless oxygen cylinders during the whole of that period, thereby greatly restricting the distribution of a gas which, in the opinion of many qualified judges, was of even greater importance. It must be admitted that the large airship programme which was to justify the erection of national hydrogen factories and the unlimited production of large hydrogen cylinders, never materialised during the war, although many of the cylinders and considerable quantities of hydrogen, ultimately became available for valuable war service of a different character. The number of hydrogen cylinders

manufactured has, however, largely exceeded these latter requirements and, with reasonable departmental co-operation, many thousands might have been released for the distribution of oxygen at a time when they would have been invaluable for that purpose.

These hydrogen cylinders are, for the most part, constructed to hold 400 cub. ft. of gas when charged to the standard pressure of 120 atmospheres. They are seamless and of good construction, the steel containing carbon slightly in excess of the proportion we have advocated above for industrial cylinders, with the wall thickness slightly less. We believe that upwards of 100,000 of these cylinders have been manufactured during the war at a cost exceeding 1,000,000*l.*, and statistics as to the average number of times each cylinder has been filled would be interesting. Some will no doubt be retained in military service, but large quantities can surely now be released for other purposes. They are unfortunately much too large for ordinary industrial use, but they could no doubt be cut in two and made up into smaller sizes, when at reasonable prices, a considerable proportion would find an immediate market in the compressed and liquid-gas trade which, because of these very cylinders, has been starved in its normal supplies during the war. They are the best and most trustworthy cylinders that have been manufactured in that period and, if only half their number is converted, as we have suggested, they should be sufficient to provide an adequate supply of the largest trade cylinders for many years to come.

Immense quantities of other cylinders have been manufactured for Government departments during the war and many of these, unless they are destroyed, may find their way into the compressed gas trade and become a source of public danger. They range from very heavy lap-welded cylinders—manufactured from steel of low tenacity, which were forced upon the oxygen industry through seamless cylinders being unprocurable—to very light oxygen cylinders produced from special heat-treated steel, the tensile strength of which often exceeds 55 tons per square inch with a yield-point only a few tons lower. These cylinders when charged with gas to a pressure of 120 atmospheres, have a working stress in their walls of 20 tons per square inch. Many thousands were completed shortly before the armistice for the supply of oxygen for respiration on aeroplanes at great altitudes. For this purpose light cylinders were no doubt desirable, although we venture to think that condition has been obtained by a needless sacrifice of security. It has, however, been seriously suggested that these cylinders should be employed for hospital and general medical use, and other purposes where lightness is claimed to be an important factor. We have recently seen a pamphlet issued by well-known makers of engineering articles, who, since the war, have taken up the manufacture of oxygen appliances, and in the pamphlet cylinders of this type are actually advocated on the grounds that they are less than half the weight of corresponding standard trade cylinders. There is no suggestion in the pamphlet that these cylinders should be specially watched for deterioration or handled with exceptional care. It is merely implied that they are to become ordinary cylinders of circulation, to be subjected to the well-known delicate handling of railway porters and lorry men, without apparently any thought as to existing regulations or the heavy burden of additional anxiety which such cylinders would impose upon the filling factory.

We have written enough to indicate how Government departments with their unrestricted powers of expenditure, lack of co-operation with each other, and without any reference to the established trade, have bequeathed to it a legacy of trouble. We now understand that a Cylinder Committee has been appointed, mainly on the initiative of the departments responsible for this superabundant and mixed assortment of cylinders, and the chief object of the committee is to revise existing regulations, with a view to the introduction of lighter cylinders in a trade which claims to be well qualified to look after its own affairs. The trade is not, so far as we have been able to learn, even to be represented on the committee, although officials of the departments responsible for these war-time cylinders are, we understand, much in evidence. Were it not for the fact that the committee includes others, whose knowledge of cylinder matters is not of recent growth and goes beyond mere questions of metallurgy, the trade would be justified in disregarding any recommendations which may ultimately be issued for its enlightenment. These more experienced members may, we trust, be relied upon to give full consideration to the trade view of this matter and to sanction no reduction in the weights of cylinders which is obtained at the cost of security.

This question is not without interest to engineers, many of whom are to-day large users of gas cylinders. They will agree, we think, that the difference of a few pounds in the weight of cylinders is relatively unimportant, and that high tenacity in steel, which is obtained by methods of heat treatment during the manufacture of cylinders, is not sufficiently uniform and reliable to warrant the use of such material to reduce the weight of cylinders continually subjected to rough handling during transport and in workshops. We cannot regard the present advocacy of such cylinders by Government departments as strictly disinterested, nor the support which they appear to be receiving from certain cylinder makers. We have recently seen letters addressed by Government departments to cylinder users, which can only be read as indicating the intention of competing with the trade in the supply of certain gases. A revision of trade regulations which would enable large stocks of Government cylinders purchased during the war to be employed for that purpose—and which incidentally must depreciate the value of upwards of 200,000 privately-owned cylinders—would be a useful preliminary step in that direction.

If we are doing some members of the committee an injustice, and if they have really the best interests of the trade at heart, they can prove this by advocating modifications of the existing regulations only to the extent which we have indicated, and by confirming for all time the present withdrawal of that most useless and even dangerous condition regarding the employment of cylinder covers. On both of these points we are convinced that the railway companies and other public carriers, would readily agree. If, furthermore, the Committee desire to help the industry to quickly recover ground lost during the war in the matter of cylinders, we venture to suggest that they make the following recommendations to the Government: (1) To release considerable quantities of large hydrogen cylinders on fair terms for the purpose we have indicated. (2) To gradually call in and scrap as such all the heavy lap-welded cylinders which were supplied to the trade as a stop-gap during the war. (3) Either to retain the very light oxygen cylinders purchased for military aeroplane use, strictly for that purpose, or to destroy them. (4) To carefully exclude from the gas cylinder market, and either scrap or hold until some other use can be found for them, all trench warfare and other special gas cylinders which fail to comply entirely with trade regulations. Such a policy with regard to war-time cylinders would gradually restore confidence in the industry, and we venture to think that it is the wisest way in which the Government can dispose of the vast stocks which they have accumulated.

DIRECT-CURRENT SWITCHGEAR FOR INDUSTRIAL ELECTRIC MOTORS.

ALTHOUGH there will always be cases in which groups or lines of machines, have one common drive, whether electrical or otherwise, it is probable that separate power units, will be installed in rapidly-increasing numbers. In many industries, the speeding-up which has taken place in recent years is much more in evidence in the time in which the work is actually done, than in the time taken in preparing, or setting-up the machine for each operation. This is now true to such an extent, that we see many cases where more time is taken up in loading, setting, bolting down, or otherwise preparing for the work, than in actual running. When machines are driven from one common line, the power loss and extra upkeep necessitated in these instances is considerable, and is a potent argument in favour of the separate drive. It may also be pointed out, that a running belt, and a quickly-rotating loose pulley, or clutch member, on the same machine, are factors which are certainly not conducive to speeding-up the loading; and, moreover, many serious accidents are due to this cause, and it is probable these will increase as times become more strenuous.

We may therefore assume that the single motor drive will become more popular, and the electric motor is best fitted for this purpose. One reason, among many, why this is so is that the control gear can be made handy, simple to work and capable of starting, stopping, reversing or inching, at a moment's notice. Control may be exercised from any point, near or remote, or from several chosen spots.

The average manufacturer finds one obstacle looming large in the path to this "El Dorado" of touch-and-go, namely, the question of both initial and running expenses. For dealing with this matter he should first determine where the single drive will cut out most losses in his works, and which of the above features it will pay him to adopt. He must next consider the type of man working on the machine, and the location of the control gear. It may be said at this juncture, that inasmuch as the most intelligent workman has his moments of aberration, and any situation may be at times dusty or wet, a foolproof, fully-enclosed switch, is generally the best investment. Also, remote control for starting and stopping, is very cheap as an addition to suitably designed gear, inching is slightly dearer, whilst reversing almost doubles the cost, although there are cases where it is worth while to instal it (owing to the machine being likely to "jam" for instance, when much time and labour would be wasted in backing-off, if this were not fitted).

There are many types of high-class controls on the market, and in this connection it may truly be said, that the upkeep cost is in inverse ratio to the initial outlay. For motors of, say, 10 h.p. and upwards the resistance should never be less than 2-minute rating, in order to avoid trouble when starting frequently.

The totally-enclosed, pillar type of switch, as made by all the leading makers, is very suitable for many purposes; it is usually built up of several units, any combination of which, may be assembled in one case. For instance, the starting equipment for a shunt-wound motor may consist of:—

(*a*) A double-pole cut-out, often mounted in a locked compartment.

(*b*) A panel fitted with two overload circuit-breakers, together with an inching contactor.

(*c*) Rheostat panel for speed regulation.

(*d*) Faceplate starter panel, fitted with no-volt release.

(*e*) Ammeter and voltmeter.

The mains usually enter at the bottom of the switch, the above outfit being lettered from the ground, upwards.

The buyer will find the list contains prices for (*a*) and (*d*) with extras quoted for the other features.

The resistance grids are mounted behind the panel, as also all connections between the parts are at back of the panel. This entails the switch being pulled away from the wall when in need of repair. One enterprising firm has developed a double-hinged equipment, the back of which is fastened to the wall, a compartment containing the panel with resistance on the back and switches on the front, is hinged to the back, a glazed door being hung to this. All connections are at the hinged side, and are flexible, the whole thing opens like a book, and is extremely convenient and accessible.

There are many cases where the machine has to be started and stopped very frequently, either by hand or automatically. For this service, auto-contactor starters are rapidly gaining favour. In the types previously described, the inching and stopping is usually done by push button, but the actual starting is by means of the handle, which cuts out the resistance and so accelerates the machine, at a rate depending on the judgment of the operator.

In the cases now under consideration, this method has several grave defects, the acceleration is not always uniform, the operation takes anything from 10 seconds to 40 seconds, at which time the worker

is stationed at the switch instead of watching the starting-up of his machine, and, finally, where a loose pulley or similar declutching device is fitted to the machine, or where the motor drives a fan or pump, in which the supply can be turned off, the motor is left running during idle machine times. In other cases, such as accumulator pumps, air compressors, conveyors, &c., the attendant may be dispensed with by using automatic starters.

Many firms are now developing cheap methods of producing these equipments, and the auto-starter lends itself to this, as it consists of four or five "clappers," all interchangeable. This fact in itself is worthy of note, as, whereas in other types of starters, many and varied attachments have to be stocked as spares for upkeep; in this, all that is needed is a spare contactor, complete. Also, in cases where it might be deemed necessary to standardise still further, the same size contactor may be used in parallel, in switches of double the normal capacity. In one case in which this was done it was found that the fact of the switch being in duplicate, provided additional safeguard against stoppage as, if one contactor went wrong (a very rare occurrence by the way), the other "carried on."

The first point which strikes the casual observer, on examining a contactor, is their rugged build. We are so accustomed to think of switchgear in terms of small pivoted levers, carbon tips, and fine hair-like wires, that it is with some surprise we see, on examining the new contactors, the simple and massive units, exactly similar, and widely spaced, and note the complete absence of those details, which, in practice, gave so much trouble in other types of gear.

The action of these contactors is very interesting, each contactor (except the first) being controlled by what is termed a lockout coil. We see a cast or pressed steel lever, pivoted near the centre, at the top end of this is a copper contact which starts the motor when this end is pulled in. Immediately below this, is a shunt coil, which tends to close this contact, when the "start" button is pressed.

On the first unit there is no "lockout coil" to prevent this, and so the motor starts, with all resistance in the armature circuit. The second unit has a coil of strip copper, below the fulcrum, in addition to the shunt coil above as previously described; and as all the current which is, at the moment, accelerating the motor, passes through this series coil, its magnetic strength is sufficient for a time to overpower the top "shunt" coil, and thus "lock out" the second contactor from coming into action. As the motor gathers speed, however, this initial starting current grows less, until it reaches some pre-determined power, at which point the lessened magnetic effect of the bottom or lock-out coil is overpowered by the constant pull of the shunt coil, and the contactor is pulled in, thus cutting out a step of the resistance, and again accelerating the motor. This locks out the third contactor, and the cycle of operations is repeated until the motor is up to speed. It should be said that the steps are easily adjustable on site, to suit working conditions, and being rigidly locked, cannot alter in working.

The button does not need to be held on, but is simply pressed and released, and by this movement the motor is started up as evenly as if attended by the most highly-skilled electrician, during which period the machine attendant is at his normal work.

Another type of contactor has a time-lag lock-out, in which the "pull-in" coil has to drag an oil-immersed piston up a cylinder, the escape of the oil, and therefore the speed of action, being regulated by a screw. Once set, these are very good so long as the load at starting and the working conditions remain the same. They certainly require more skilled attendance than the current lockout type, the trip levers and other details being small and oft-times rather complicated; but in some factories the skilled attendance is more plentiful; due to other causes. After a little wear the oil oozes through the cylinder cover, and it is usually almost impossible to prevent this occurring.

A third type of lockout is of what is known as the thermal shunt type. This makes use of the fact that some metals, iron for instance, carry less current when hot than when cold. The lockout coil, in this case, is of iron strip, but is made of such a capacity that it locks out when only part of the total current is passed through it; the remainder being shunted through a strip of resistance composed of metal capable of carrying the same current at any heat, within limits. With a light starting torque sufficient current is not passed to heat the coil, and the action is similar to that in the first contactor described in this article, the coil releasing the clapper as the amperes decrease; but a more complex action takes place when a heavy starting current is needed. This is due to two opposing factors. We have the comparatively large initial flush of current, causing the coil to rapidly heat up; and on the other hand we see this heating tendency decrease as the current falls due to motor acceleration. The first factor weakens the pull of the coil, the increased resistance due to heat causing more current to be passed through the shunt, the second factor decreases this resistance, enabling the coil to take a larger proportion of the decreasing load. The result, when the coils and resistance are properly proportioned, is a beautifully modulated starting torque, under widely varying conditions of load.

In conclusion, it may be pointed out to the manufacturer who may at the present time attach much importance to first cost, that the equipments described in this article although fully developed as regards design, and lending themselves as they do to the methods of mass production in which great experience has been gained in the past four years, have not as yet had their manufacturing conditions fully stabilised. We may therefore, it seems reasonable to hope, look for some considerable reduction on present prices, and until these occur, it behoves him to exercise discretion in buying switchgear, which at a comparatively early date he may be desirous of replacing.

THE TRANSATLANTIC FLIGHT.

On Sunday last the Vickers' Vimy-Rolls aeroplane landed at Clifden, Ireland, after having completed the first direct flight across the Atlantic from St. John's, Newfoundland. We illustrated and described the machine, and gave some particulars of the arrangements for the flight on page 604 *ante*, so that we have now only to record the successful accomplishment of what is undoubtedly the most remarkable feat in aviation so far achieved. The machine, piloted by Captain J. Alcock, D.S.C., and navigated by Lieutenant A. W. Brown, crossed the coast line at St. John's at 4.28 p.m. (Greenwich time) on the 14th inst., and the Irish Coast near Clifden at 8.25 a.m. on the 15th, having covered the intervening distance of 1,880 miles in 15 hours 57 minutes, which gives a mean speed of nearly 118 m.p.h. This high speed, however, was partly due to a following wind, since in order to economise petrol the engines were throttled down so as to give a speed of about 90 m.p.h. in still air. Actually the petrol supply was ample, as about one-third of the total quantity of 856 gallons remained in the tanks at the end of the journey.

Except for the following wind the weather conditions during the flight were by no means favourable, fog and low-lying clouds, which frequently obscured both sea and sky, persisting for practically the whole of the distance. For this reason, Lieutenant Brown was only able to check his position by astronomical observations on four occasions during the journey. The comparatively slight deviation from the course, which was set for Galway Bay, is, however, sufficient indication of a highly creditable performance in aerial navigation. This is all the more remarkable on account of the fact that the wireless generator failed almost immediately after the start, so that no communication with ships, for the purpose of checking the position of the aeroplane, was possible.

Difficulty was also experienced owing to the clogging of the air speed indicator with ice, but, in the main, the machine and its engines functioned perfectly, and, indeed, the fact that the journey was completed at all is sufficient evidence of this. The flight of an aeroplane is dependent upon the proper working of so many minor, but essential, details that exceptional care and skill must be given to the design of these parts, especially when, as is the case in a long flight over the sea, the failure of any one of them may be attended with fatal results. It will be remembered, in this connection, that Mr. H. G. Hawker's splendid attempt at the Atlantic flight, made four weeks earlier, on the Sopwith machine, failed only on account of the clogging of a strainer in the water-circulating system. The only really untoward event in connection with the flight of the Vickers' Vimy-Rolls machine occurred at the end of the journey, when, owing to the fact that the landing was made in boggy ground, the machine turned over on to its nose, and the lower plane was somewhat damaged. The pilot and navigator were, however, quite unhurt, and they are to be congratulated on this account, as well as on the accomplishment of an epoch-making flight. We also offer our congratulations to the staff and workers of Messrs. Vickers' Aviation Department for the part they played in the production of the machine, and especially to Mr. R. K. Pierson, to whom the credit for the design is due. With them must be coupled the designers and constructors of the Rolls-Royce engines used on the machine. The engines, we are informed, worked perfectly throughout, and this fact accounts, in no small measure, for the success achieved.

Doubtless the first transatlantic flight will be followed in the very near future by several others, as the fact that the prize of 10,000*l.* offered by *The Daily Mail* has been awarded will not deter the other competitors from making the attempt as a supreme test of the performances of their machines. We do not, however, share the view expressed in some quarters, that the Atlantic flight by aeroplanes will soon become a daily occurrence. Possibly, in the not far distant future, it may become a fairly easy journey for a large multi-engined seaplane of the flying-boat type, but, in our view, lighter-than-air craft, as represented by large rigid airships, are more suitable for long journeys over the sea, and these, we think, are more likely to become a commercial proposition.

NOTES.

Memorial Service at Westminster Abbey.

On Wednesday morning last an impressive service was held at Westminster Abbey in memory of engineers connected with the chief professional institutions, who gave their lives for their country during the war, 1914-19. The spirit which animated the service was so admirably indicated by the Dean in a brief but most eloquent address, that we cannot do better than quote from it as follows:—"Let us now praise God for our brethern belonging to the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Naval Architects, the Institution of Electrical Engineers, and the Iron and Steel Institute, who have laid down their lives for their King and country in the great war. They were men who were drawn from posts of great responsibility and high scientific distinction. They surrendered to the service of their country the gifts of their industrial skill and the riches of their professional experience. In every field of warfare, by sea and land and air, they have won an honourable and immemorial record of great achievement. They were the pride of their homes. They went out in the beauty of their strength and manhood. Their sacrifice has been the price of our country's complete and final triumph. In sure and certain hope of our joyful reunion with them in the day of Resurrection, we now commit the keeping of their souls unto Him who is eternal love and eternal life." The service was very largely attended. From a "roll of honour" appended to the details of the service we learn that the number of members of all classes lost during the war by the Institutions named above were as follows:—Institution of Civil Engineers, 331; the Institution of Mechanical Engineers, 88; the Institution of Naval Architects, 23; the Institution of Electrical Engineers, 150; and the Iron and Steel Institute, 17.

Graphite, Graphitic Acid and Amorphous Carbon.

When Debye and Scherrer, examining diamond, graphite and amorphous carbon by means of X-rays a few years ago, came to the conclusion that there are only two allotropic modifications of carbon,

colourless diamond and black carbon, they confirmed the view held by most recent investigators of these problems. The popular belief still favours the three modifications, although it is hardly possible to draw any distinct line of demarcation between graphite on the one hand and amorphous carbon (soot) on the other. Graphites from various localities or prepared in various ways differ strongly in properties. The density may be anything between 1·8 and 2·35; the hardness lies between 0·5 and 2; the electric conductivity and its temperature coefficient fluctuate much; graphite is said to be crystalline, but perfect crystals and even distinct cleavage of planes are hardly known; no graphite contains 100 per cent. of carbon, and as a matter of fact there is a continuous series of gradations between the extreme forms mentioned, graphite and soot. In two papers, contributed by V. Kohlschütter and the late P. Haenni, of the University of Bern, to the *Zeitschrift für Anorganische Chemie*, vol. cv, pages 35 to 68 and 121 to 144 (December, 1918, and January last), the whole problem is reviewed, and the formation of graphitic acid is studied in particular. By heating graphite with energetic oxidising agents, potassium chlorate and sulphuric acid, to which Kohlschütter adds nitric acid, graphite—not amorphous carbon—was known to be converted into a solid graphitic oxide or graphitic acid; the former was said to be green, the latter yellow, but the colour might also be brown or blackish; different graphites were said to give the one or the other oxide and were classified on this basis. Kohlschütter and Haenni find that the colour depends upon the conditions of the reaction and not upon the origin of a graphite, and that graphitic acid does not form crystals, but merely pseudomorphs more or less filling up the space previously occupied by the graphite. The composition of the graphitic acid varies; there are about 2 per cent. of hydrogen and from 39 per cent. to 44 per cent. of oxygen, the rest being carbon and moisture. Balbiano suggested recently that graphitic acid was merely an adsorption product of carbon, CO, CO_2 and water vapour, and Kohlschütter first inclined to that view; but he does not adhere to it, though he cannot settle the formula of the acid. Heated or treated with reducing agents, graphitic acid loses CO, CO_2 and water, and turns into carbon with more or less violence; the final product contains 99·7 per cent. of carbon and is sooty, but becomes graphitic upon being compressed. When graphitic acid is decomposed in sulphuric acid at 170 deg. C., a substance intermediate between soot and graphite is obtained. Amorphous carbon treated with the oxidising agents referred to is completely turned into gaseous CO, CO_2 and water, whilst the graphite forms the solid acid; graphite, on the other hand, swells when treated with nitric acid. Going back to graphite, Kohlschütter states that it is mainly formed by "topochemical reactions," that is, localised reactions taking place in limited space. They are chiefly surface reactions (*e.g.*, decomposition of acetylene), reactions *in situ* (decomposition of a carbide, as in the Acheson process), or surface layer reaction (decomposition of carbon disulphide). In Nature graphite was probably produced mainly by the metamorphosis of organic carbon compounds in contact with igneous rock and by the decomposition of CO in clefts. Graphite itself is not really crystalline, but forms pesudomorphs like its acid, and the differences between graphite and amorphous carbon are essentially physical and structural. That would account for the differences in the specific heat and density of the two varieties which are sometimes regarded as evidence of their being allotropic modifications.

AMALGAMS RICH IN GOLD.—In continuation of their researches on gold amalgams, N. Parravano and P. Jovanovich (*Gazzetta Chimica*, 49, pages 1 to 6, 1919) prepare gold amalgams by coating gold wire, 0·5 mm. in diameter, electrolytically with mercury, heating the coated wire to 200 deg.; coating again, and repeating this process several times until they get rich amalgams. The pure gold and the 21 amalgams ranging in mercury content from 0·4859 per cent. up to 0·593 per cent., were then analysed and examined microscopically, and their electric conductivity was tested. It was found that the conductivity decreased continuously as the mercury percentage increased. This fact would tend to support the conclusion previously arrived at that the mercury forms solid solutions with the gold.

LITERATURE.

Metallurgy of Lead. By H. O. HOFMAN, E.M., Met.E., Ph.D., Professor of Metallurgy, Massachussets Institute of Technology and Harvard University. New York: McGraw-Hill Book Company; London: Hill Publishing Company. [Price 30s.]

WITH rapid progress in the industrial arts due to improved technology, text-books describing processes and methods grow obsolete and need constant revision. Then a time comes when excision and repairing no longer suffice and entire remodelling must be undertaken. Such an epoch has arrived in the history of Professor Hofman's work on the "Metallurgy of Lead and the Desilverisation of Base Bullion," and this treatise replaces the well-known manual. Only the chapters describing the methods of the reverberatory smelting of lead ores and the German cupellation process retain something of their original dress; the former because it presents the chemistry of the process in a simple manner, and the latter, as it enables cupellation to be studied more satisfactorily than in later forms. Excessive detail can easily obscure general principles, and the object of the author is not only to describe what has been effected, but to show the reason for the successive steps.

Only a comparatively small part of the book is devoted to the properties of lead, its alloys and compounds. Much chemical work has been effected of late on industrial lead alloys, and this section might have been enlarged with advantage. The subject of eutectic mixtures scarcely receives the attention it deserves, the author having apparently decided that it was undesirable that such topics should compete in interest with the main subject of lead smelting. The copious references and bibliography attached to each page and every chapter make amends, however, for any deficiency.

The industry is a sufficiently large subject, involving much detail. The world's production of lead in 1913 amounted to 1,142,264 tons, to which total the United States contributed 396,000 tons. Owing probably to war demands, in 1916, the domestic sources rose to 600,000 tons, but there is no evidence of further great increase. The import of foreign ore is small, so that the United States output can hardly be less than one-half of the world's production. The distribution of ores throughout the country is fairly general, but some of the less productive mines have been abandoned and some are decreasing in yield. The two minerals that are worked for lead are galena, giving rise to sulphide ores, and cerussite, the main source for the so-called carbonate ores. Lead occurs in many other combinations in various minerals, but these have little commercial value and may be regarded as mineralogical curiosities. The non-argentiferous galena occurs in the Upper Mississippi Valley and the State of Missouri. Utah and Idaho have important argentiferous lead, mainly in carbonate ores. Nevada is still an important mining centre, but its production is diminishing. On the Atlantic Coast States, the lead mines formerly worked supply but a negligible quantity, lead smelting having become subordinate to the zinc.

Metallic lead is extracted from its ores exclusively by smelting in carbon-heated furnaces, the method that the Phœnicians probably followed with success. That no generic change has been effected implies that the operation is fairly simple, heat playing a great part in the chemical reactions. Electric furnaces have been proposed, especially when zinc lead sulphides are present, but have not found general favour. Electrolytic methods have been applied to complex zinc-lead ores with good effect, but such process belongs more properly to the metallurgy of zinc than that of lead. Accordingly the variations in metallurgical processes are limited to the use of different forms of furnace, the reverberatory now little used, the open-hearth which finds useful application to particular ores, and the blast furnace which obtains the widest application, as it can treat various classes of ores expeditiously and economically in large quantities. Heat and heat alone is the main factor in promoting chemical reactions. In the reverberatory furnace the process is based upon the interaction of PbS, PbO and $PbSO_4$, Pb and SO_2 being liberated on the application of heat. The introduction of lime and of carbon at some points in the process complicates the reduction somewhat, but the equations generally offer no difficulty.

The limitations and the advantages of the reverberatory furnace are easily apprehended. The ore can be treated in a raw state, in inexpensive apparatus using an inferior fuel, though some authorities insist that each ore is best treated by fuel specially selected. Hardly any fluxes are needed, the bulk of the metal is extracted in a pure state at a comparatively low temperature with little loss from volatilisation, and if the ore is argentiferous the larger part of the silver follows the lead, and the residues can be treated at a higher temperature in the blast furnace. On the other hand, the reverberatory furnace demands a rich galena, or a rich mixture of galena with carbonates, and should not contain more than 5 per cent. of SiO_2. Further, non-silicious associated minerals such as blende, pyrite, calcspar, may be present only in small quantities. In the use of such furnaces, the two operations of roasting and reaction must be carried out separately and repeated. Roasting should be effected at a low temperature and ought to proceed as far as the theoretical limit of one equivalent of sulphate, or two equivalents of oxide, for each equivalent of sulphide. As it is not possible to roast a large mass of lead ore uniformly in one operation, all the lead is not extracted in the first reaction. Several repetitions are necessary to exhaust the lead, and as the process is continued, there may not be sufficient PbS left to react on the excess of $PbSO_4$ and PbO. Lime and coal are generally supplied to assist in decomposing the sulphide. On the completion of the process there will be left several products of smelting besides the lead, which in the form of grey slag, flue dust, and hearth bottom will generally be treated in the blast furnace, according to the degree of impurity or value of the compounds present. Variations in practice are many and the furnaces assume different dimensions and character, depending on the ore to be treated, but the author allows no point of importance to escape him. The comparisons of the results from furnaces differently constructed and differently worked in Carinthia, in England, and in Silesia, are particularly interesting, and would be more so but that the employment of the reverberatory furnace is waning. In Missouri, for example, in 1877, the number of such furnaces in operation was 56, in 1914 the number was reduced to four.

The smelting of lead ores in the ore-hearth is, however, increasing. In 1914, Missouri operated 75 ore hearths, with an annual capacity of 230,000 tons of galena concentrates. The main difference in practice from the reverberatory consists in performing the roasting and reaction simultaneously in one process, and in employing carbon as a reducing agent, the charge floating on a bath of lead. The hearth requires an ore rich in lead, and in the process much lead is volatilised. The greater favour with which the ore hearth method is regarded is due to the introduction of methods that recovers all that is valuable in this dust and fume. The bag-house, the main instrument in the recovery, is, however, very costly to erect and expensive in operation. In the system of filtration, which is the method employed, the number of bags may be as many as 3,000 or 4,000, each 18 in. in diameter and about 30 ft. long. At Midvale, Utah, 25,000 sq. ft. of filtering surface is provided per ton of fume collected per day. The life of the bag does not seem to be long, but much depends upon the quickness with which the gases are withdrawn, implying the provision of large fans and long-cooling settling flues. This refers to blast-furnace practice. In some cases it is stated the bag-house is an unprofitable addition, and its inevitable expense has led to attempts to precipitate fume by means of electrostatic charges. The Cottrell process, first introduced into copper smeltries, is found to be commercially successful, and seems applicable to the ore-hearth smelting methods. It depends upon the action of a high potential unidirectional intermittent current passing from discharge electrodes through an air space to collecting electrodes. The air becomes ionised; the suspended particles are

bombarded by the ions, and the particles gather sufficient electric charge to move under the force of the electric field. Besides the bag-house and the Cottrell electric precipitation process a third factor has operated in favour of the ore hearth. This is the Newman mechanical furnace, which diminishes the manual labour and protects the workmen from the lead fumes. With these improvements a new life is opening before the ore-hearth method, more especially as in practice it is found possible to start and stop the hearth without large consumption of fuel or loss in heat.

Professor Hofman devotes one-half of his book to descriptions of the process and the improvements that have been effected in the blast furnace as applied to lead smelting. If it is remembered that an ore containing more than 4 per cent. of SiO_2 must be treated by blast-furnace smelting, and that all lead ores can be conveniently treated in the same way, the space devoted to this section will be understood. Moreover, as the argentiferous ores of the Rocky Mountains and the Pacific Coast contain much more than this amount of SiO_2, this method of smelting possesses more than usual attractions for the American reader. As a rule in the United States, all the ores received pass to the blast-furnace charge, being variously apportioned to form suitable mixtures as regards lead content, to the collection of other metals in a matte, and to ensure that the final waste product carries no metal of value. The general process is not difficult to grasp, but the many modern modifications introduce an almost bewildering amount of details, into which the author enters with conscientious determination to exhaust the literature of the subject. Fortunately, the numerous and excellent illustrations are a great assistance in following the text.

The process in the ore blast furnace is essentially one of reduction, and as a preliminary it is usual to resort to roasting or blast roasting, in order to drive off as much sulphur as possible in the form of SO_2. Blast roasting offers many advantages over oxidising roasting and these are not only urged with forceful cogency, but the reasons for each step are clearly enunciated. The theory can hardly be regarded as satisfactory, but the explanation offered by Richter is accepted. He regards blast roasting as an enforced ordinary roast, similar to that taking place in the hand-reverberatory furnace, but this leaves unexplained the action of CaO as a flux. The incompleteness in the theory is unfortunate, for a more correct knowledge of the chemical and thermic changes in the process might suggest important improvements in the technology. The mechanical operations with their many modifications are very thoroughly discussed. Both the Huntington-Heberlein and the Dwight-Lloyd processes are exhaustively treated, as, indeed, are some other forms of up-draught blast-roasting processes. The advantages of the Dwight-Lloyd method do not stand out so prominently as anticipated. Professional authorities seem agreed that in the cost of installation, the adaptability to charge and in metal loss, the Dwight-Lloyd method is balanced by that of the Huntington-Heberlein. The lower cost of roasting and the better physical condition of the product are disputed, but it is generally conceded that the Dwight-Lloyd machine furnishes a more porous product than does the pot of its competitor.

The construction of blast furnaces, the method of operating, the treatment of the resulting products, are all comprehensively described. It is impossible to do justice in a notice to the industry that has summarised and digested a large literature, or to the skill with which the main features are presented. For the process of smelting is lengthy. Where the furnace has completed its work and produced perhaps 96 per cent. of soft lead, the treatment of the remainder gives rise to a variety of operations. The precious metals have to be extracted from the lead bullion, the copper to be concentrated in a rich matte, and other operations which generally mean re-treatment in the blast furnace.

The only operations to which a brief reference may be made are those connected with cupellation and the desilvering of base bullion. The process long followed consisted in melting and heating the argentiferous lead in a reverberatory furnace, to the temperature at which litharge forms freely on the surface. This can be run off and absorbed by the hearth, while the silver, with less affinity for oxygen, remains behind in a metallic state. If the lead bullion is poor in silver, assaying less than 30 oz. to the ton, this process ceases to be remunerative on account of loss in metal, and to the inferior grade of lead obtained from the reduction of litharge. Electrolytic processes have not generally been successful, with the exception of that due to Mr. A. G. Betts, which may be said to be still on its trial. A fairly satisfactory remedy has been found to consist in concentrating the silver into a smaller amount of lead before cupelling. The Pattinson process which is readily explicable by the application of the laws of solution, consists in cooling low grade lead bullion to its freezing-point, when crystals of lead will separate which are much poorer in silver than the original bullion. By removing these and adding fresh material, it is possible to obtain a large quantity of lead containing little silver, and a small amount of enriched lead that can be profitably submitted to cupellation.

The alternative process of Parkes, which is generally followed in America, and if the lead bullion is not particularly rich in bismuth is always preferable to the older method of Pattinson, is founded on the fact that silver has less affinity for zinc-bearing lead, than for either zinc or pure lead, and therefore argentiferous lead can be desilvered by stirring zinc into melted lead bullion. An alloy is formed, which, being less fusible than lead and with a lower specific gravity, becomes hard, and floats on the surface of the lead, from which it can be easily removed and treated separately. The flow sheets giving details of the Parkes process are elaborate, and indicate very clearly the several steps of a highly complicated operation.

The Betts' process, adopted in only a few plants, is planned on the multiple system used in the electrolytic refining of copper. "Cast anodes of lead bullion and lead cathodes cast in sheet form, connected in multiple, are suspended from copper bars across an oblong vat, which is charged with an electrolyte containing lead fluosilicate and free hydrofluosilic acid. The current enters the anodes, passes through the electrolyte to the cathodes, dissolves the lead from the anodes and deposits it on the cathodes." The precious metals and others are recovered from the anode mud, adhering to the undecomposed anodes, or deposited at the bottom of the tank. The Betts' process furnishes a high yield of refined lead free from bismuth, but retains more silver than does the lead resulting from the Parkes method. The cost is 50 per cent. higher than that of zinc desilverisation. The selection of the most appropriate method will be decided by the bismuth content.

A final chapter is added on the dangers and risks of lead poisoning, pointing out the remedies and precautions that should be adopted.

Handbook of Mathematics for Engineers. By EDWARD V. HUNTINGDON, Ph.D. With Tables of Weights and Measures by LOUIS A. FISCHER, B.S. New York: McGraw-Hill Book Company, Incorporated; London: Hill Publishing Company, Limited. [Price 7s. 6d. net.]

THIS book, which comprises a considerable amount of information useful to a trained mathematician, is a reprint of certain sections of the "Mechanical Engineers Handbook (1916)," edited by Professor Lionel S. Marks. Its design is apparently twofold: to act as an *aide memoire* by supplying a list of mathematical formulæ which experience has shown to be useful to the engineer, and secondly, to collect within a handy space a number of tables, sufficiently extended to prove of practical service. These two objects are admirably fulfilled. The tables include, among others, logarithms of numbers and of trigonometrical functions, tables of squares and cubes of numbers, as well as of roots and reciprocals. The combination of these and of several others within a small compass necessarily imposes a limit to accuracy, and to sensitiveness, and on this account the number of decimal places or significant figures has been limited to four. This degree of accuracy is sufficient for many purposes, interpolation is easy, and can be effected at sight. No indication is given whether the final figure has been increased, but such a refinement is perhaps not necessary. Such tables are of very frequent occurrence, but others are given that are not so well known, but which facilitate calculation. Among these may be mentioned values of the volumes of spheres, &c., with argument, diameter. Room is also found for a table of hyperbolic logs, and of hyperbolic functions. If, too, the engineer has to busy himself with compound interest and value of annuities he is supplied with tables which claim an accuracy beyond the four decimal places, which have hitherto served.

Beyond this point, Mr. Huntingdon apparently did not feel capable of carrying the tabular information, and leaves to Mr. Fischer the task of explaining how many pints make a quart or how many square yards are contained in a rod, pole or perch. Possibly Mr. Huntingdon felt that our weights and measures were not designed on a sufficiently scientific basis to be worthy of his attention. As, however, various systems are unfortunately in use, we acknowledge the practical value and completeness of the conversion tables which are very conveniently arranged. If it be necessary to give the values of foreign coins in a book of this character, Mr. Fischer might have remembered that there is such a coin as the English sovereign, and expressed the monetary units of various countries on this basis, as well as that of the American dollar. It may not be of much consequence, but we would ask if it is correct to say that the sidereal day "is the interval between two consecutive transits of some fixed celestial object across any given meridian." Definitions should be exact, and such loose wording as this indicates neither a day of uniform length, nor when the day begins. To substitute the first point of Aries for some fixed celestial object gives precision and accuracy.

The second section, entitled "Mathematics," covers a wide range, but offers very little teaching or explanation, the authors may, however, be correct in suggesting "that it is more comprehensive than any other similar work in English." The limited space permits little more than a statement of facts or collection of rules which have to be followed to obtain a definite result. The adoption of this method enables Mr. Huntingdon to start with the rules of simple arithmetic, give a very good description of the slide rule, and to excite, without satisfying, our curiosity as to the construction of computing machines. We are hurried through the elementary rules of geometry and mensuration, shown how to solve an algebraical equation and presented with a page on the properties of determinants. In the same breathless way, the fundamentals of plane and spherical trigonometry are reviewed. Analytical geometry contains a chapter on the theory of the catenary and some other curves of which it may be said that the collected formulæ and the tables are likely to prove useful. A few pages are devoted to differential and integral calculus, and also to the graphical representation of functions. The explanation of the use of logarithmic cross-section paper is a welcome innovation in this class of book. Finally, a page and a half is occupied with a summary of the definitions and formulæ of vector analysis.

To any one who has read mathematics and wishes to recall some formulæ without the trouble of deriving it, this work will be very useful, and doubtless as a section of a larger work, giving fuller proofs and details of methods, it would hold a very worthy place, but divorced from its original surroundings its merits are limited.

Tabulated Weights of Iron and Steel. By C. H. JORDAN, M.I.N.A. London: E. and F. N. Spon, Limited. 1918. [Price 15s. net.]

THE seventh edition of this pocket book has recently been published, it now contains nearly 750 pages of tables giving the weights of iron and steel sheets, angle, tee, zed, bulk, channel, and other sections for all sizes and thicknesses varying in the case of the thickness by thirty-seconds, twentieths, fortieths and fiftieths of an inch, together with the sectional areas so often required when dealing with the rules issued by Lloyd's Register of Shipping or the conditions specified by the British Engineering Standards Committee. The

new edition has been thoroughly revised, and includes additional tables giving the superficial area of plates and the weights of superficial feet of steel plating.

The pocket book represents an enormous amount of work and will be of great assistance to those who have to continually deal with the weight and sectional area of the various shapes and sizes of iron and steel sections and plates used in constructional work. It will be especially useful to shipbuilders and steel manufacturers as it is a time saver, and the tables are well arranged for use in the drawing office. Care has been taken to specify whether the weights are for iron or steel, and in some cases the weights are given separately in parallel columns for iron and steel.

In using the tables it will be advisable to examine the diagram of the section on which the weights and sectional areas enumerated are based, to ensure that the constants adopted by the author are comparable with those for the profile of the section to be used in the structure.

Further sections of the book are devoted to the weights of chain cables and to Lloyd's rules for regulating equipment for steel and other vessels, while at the end are given tables of decimal equivalents and of equivalents used for conversions from the Imperial weights and measures to the metric system.

The index at the commencement of the book is good, and by printing some of the tables on coloured papers quick reference is secured.

BOOKS RECEIVED.

Kelly's Directory of Merchants, Manufacturers and Shippers of the World. 1919. London: Kelly's Directories, Limited.

The Empire Municipal Directory of Local Authorities and Officials and Year Book "Municipal Engineering and the Sanitary Record" for 1919. London: The Sanitary Publishing Company, Limited. [Price 5s. net.]

Naval Architects' Data. By J. MITCHELL, A.M.I.N.A. Edited by EDWARD L. ATTWOOD, O.B.E., M.I.N.A. London: Longmans, Green and Co. [Price 7s. 6d. net.]

The Railway Year Book for 1919. London: The Railway Publishing Company, Limited. [Price 5s. net.]

French Technical Words and Phrases, an English-French and French-English Dictionary of Technical and Business Terms and Phrases. Third Edition, revised throughout and greatly enlarged. By JOHN TOPHAM, Barrister-at-Law. London: E. Marlborough and Co.

The Mica Miner's and Prospector's Guide. By ARCHIBALD A. C. DICKSON, M.E.(U.S.A.), F.G.S.(Lond.). London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 4s. 6d. net.]

"The Studio" Year Book of Decorative Art, 1919, *with Special Articles on College Design, Decoration and Equipments.* Edited by GEOFFREY HOLME. London: "The Studio," Limited. [Price 7s. 6d. net.]

Simple Problems in Marine Engineering Design, including Algebra for Board of Trade Examinations. By R. M. SOTHERN. Fourth Edition. Glasgow: James Munro and Co., Limited. [Price 7s. 6d. net.]

The British Dominions Year Book, 1919. Edited by EDWARD SALMON, F.R.C.I., and JAMES WORSFOLD, F.C.I.S. London: The Eagle, Star and British Dominions Insurance Company, Limited.

Jane's Pocket Aeronautical Dictionary. London: Sampson Low, Marston and Co., Limited. [Price 1s. 6d. net.]

Elastic Stresses in Structures. Translated from CASTIGLIANO's *Théorem de l'Equibre des Systemes Elastiques et ses Applications* by EWART S. ANDREWS, B.Sc., Eng. (Lond.). London: Scott, Greenwood and Son. [Price 5s. net.]

Railway Reorganisation. By A RAILWAY OFFICER. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 6s. 6d. net.]

A Course in Machine Drawing and Sketching. By JOHN H. DALE, A.M.I.M.E. London: W. and R. Chambers, Limited. [Price 3s. 6d. net.]

The Vulcan Engineering Manuals. Boiler Steel and Experience with High-Pressure Steam Boilers. Manchester: Vulcan Boiler and General Insurance Company, Limited. [Price 2s. 6d. net.]

Transactions of the Institution of Water Engineers. Vol. XXIII., 1918. Edited by PERCY GRIFFITHS, M.Inst.C.E., F.G.S., Secretary. London: St. Bride's Press, Limited; New York: D. Van Nostrand Company.

The Strowger Automatic Telephone Exchange. By R. MORDIN. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 21s. net.]

Steam Power Plant Engineering. By GEORGE F. GEBHARDT, M.E., A.M., Fifth Edition, re-written and reset. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18s. 6d. net.]

New Town. A Proposal in Agricultural, Industrial, Educational, Civic, and Social Reconstruction. Edited for the New Town Council by W. R. HUGHES, M.A. London: J. M. Dent and Co., Limited. [Price 2s.]

THE ENGINEERS' PART IN FOOD PRESERVATION.

THE report of the Food Investigation Board under the Department of Scientific and Industrial Research for the year 1918 has recently been issued, and the following extracts from it are not without interest:—

The Board was instituted to organise and control research into the preparation and preservation of food. Its operations have been conducted by means of committees and the underlying principle of action has been that too great concentration upon the development of processes which will give results quickly would in the long run debase the scientific method to the level of empiricism and finally sterilise it completely.

It is admitted that scientific knowledge is insufficient in some regions, whilst in others it is fully abreast or ahead of practical needs. Thus in engineering the science of thermodynamics has reached a point from which the problems of refrigerating engines seem elementary. On the other hand, the chemistry of flavour and of the ripening of flesh lies in a region of biochemistry but little explored, and the preservation of fruit and vegetables by cold raises questions whose solution depends upon an extension of our knowledge of the metabolism of plants to low temperatures. Colloidal physics, too, is backward where its help is most needed.

Fish Preservation Committee.—This Committee has been mainly occupied with the investigation of a method known as brine freezing, in which the fish to be frozen are plunged into strong brine cooled to 10 deg. F. or lower. Owing to the high specific heat of the brine, cooling is much more rapid than in the ordinary air-freezing process, and the separation of fluid and solid in the tissues which occurs when extraction of heat is relatively slow is thereby prevented. The flesh of the fish remains firm when thawed out and colour and superficial appearance are preserved.

Engineering Committee.—This is a most important Committee and has for its object to organise research into the engineering problems which arise in connection with cold storage; and in particular to investigate and report upon questions relating to:—

1. The theory and practice of refrigerating engines and of insulation.

2. The scientific principles involved in the design of cold stores.

3. The construction and equipment of ships intended mainly or wholly for the carrying of cargo at low temperature, and the application of refrigeration to fishing vessels,

4. The type or types of refrigerating cars most suitable for use in the United Kingdom.

5. Methods of measuring and recording the temperature and moisture of the air in closed spaces.

It was decided at the outset to leave questions concerning refrigerating engines for the time being and concentrate upon the problems presented by the development of cold storage in this country, namely, the type of wagon or barge best suited for the carriage of frozen produce on our railways or waterways, and upon problems of insulation. A plant has been established for experiments upon the influence of the nature and construction of the walls upon the flow of heat in a closed space.

The changes of food preserved in cold stores are largely governed by the degree of humidity and it is therefore important to the industry to be in possession of instruments capable of recording the quantity of moisture in the air of stores, but the designing of simple and reliable instruments to measure the very low tension of aqueous vapour which exists at low temperatures is beset with difficulties.

Meat Committee.—The chief work of this Committee has been based on the fact that whereas mutton can be frozen without impairing its qualities, beef needs much more careful treatment. Freezing in the ordinary way, that is by cold air, causes a separation of fluid in the substance of the muscle fibres with the result that on thawing, unless somewhat elaborate precautions are taken, there is loss of water and soluble constituents and the texture of the meat is impaired.

Detailed determinations of the coefficients of conductivity of heat and of diffusion of salts need to be made as well as large scale experiments upon the carcases of freshly-killed beasts. Fortunately, both heat flow and the diffusion rates of salts are governed by similar equations and the theory of dimensions is applicable in its simplest form. Experiments in the laboratory on the carcases of small animals can therefore be utilised freely.

Oils and Fats Committee.—This Committee deals with a survey of the sources of supply of edible oils and fats and is particularly interesting as regards its investigation into the presence of traces of nickel in hardened fats.

Fruit and Vegetable Committee.—The work of this Committee has been hampered by a technical difficulty. Fruit and vegetables are living structures which are killed by being frozen. Experiments, therefore, must be conducted within a narrow range of temperature at or about the freezing-point, and instruments are needed capable of maintaining a given temperature within the range for long periods and very exactly. Existing thermostats are designed for the regulation of temperature above that of the surroundings by controlling the influx of heat from some source. No device for the accurate regulation of temperature by control of the influx of cold exists, and this is what is needed for the work on fruit and vegetables.

It is proposed to follow out the chemical changes occurring in fruit during maturation and storage, by investigating the chemical and physical behaviour of the expressed juice of apples stored for various periods, both under normal conditions and also at low temperatures. For such work it is very important to have a method for obtaining with ease and rapidity satisfactory samples of the sap. Various trials have been made and, as a result, the procedure now employed is to cool out portions of the apple for 16 hours to 18 hours in a freezing mixture and then express the juice with a small hand press. This method gives an extract which, so far as substances of small molecular weight are concerned, seems to afford satisfactory samples of the sap of the fruit. Substances of high molecular weight, such as pectin substances, are, however, held back to a considerable extent, for it is found that later portions of the expressed sap have a much lower viscosity than that characteristic of the early portions. This point is being investigated further.

As a complete carbohydrate analysis of the sap cannot be carried out in a few hours, it became necessary to develop a method by which the sap could be stored under conditions in which it would undergo no alteration. As a result of a number of experiments, the following procedure has been adopted. The freshly-expressed juice is neutralised with calcium carbonate, boiled rapidly to destroy enzymes and filtered. The filtrate is treated with basic lead acetate which precipitates tannins, dextrins and pectin; it is then filtered and the excess of lead removed with sodium carbonate. The solution can then be preserved under toluene for an indefinite time. It is proposed to follow the changes in the carbohydrates by determinations of the quantities of (*a*) starch, (*b*) cane sugar, (*c*) reducing sugars (maltose, glucose, fructose, pentoses) in the expressed juice.

The physical changes progressively occurring in stored apples will be studied by expressing the juice from samples taken at regular intervals and investigating (1) depression of the freezing-point, (2) density, (3) viscosity, (4) electrical conductivity, (5) concentration of hydrogen ions. The latter concentration will be compared with the acidity determined by titration. The apparatus for investigation of the hydrogen ion concentration, and that for electrical conductivity, is now in working order and a number of observations have been made. It has been shown that the presence of non-electrolytes in the sap markedly reduces the electrical conductivity; in deducing the content of electrolytes from the electrical conductivity of such sap, allowance must therefore be made for the presence of non-electrolytes. In previous work on plant saps this source of error has been entirely overlooked.

Preliminary observations upon the temperature and moisture conditions in a commercial cold storage plant have been made.

The temperature of the apples and of the air of the chamber has been taken and the humidity of the air measured. It was found that, while the humidity of the general air of the chamber was about 85 per cent., the air immediately adjacent to the apples, which are stored in boxes, had a moisture content of 98 per cent. The cooling machine, when first started, was not working up to its full power so the readings obtained of the rate of fall of temperature of the apples cannot be regarded as being normal.

DUTCH INDIES' RAILWAYS.—According to *The London and China Telegraph*, which quotes from Dutch reports, Holland intends to purchase American steel rails on a large scale during the next few years. They will be mainly used for the extension of the railways in the Dutch Indies with a view to benefiting the sugar industry. The annual purchases will probably amount to 50,000 tons.

SUPPLIES OF WELSH COAL FOR STEAM VEHICLES.—The National Council of the Commercial Motor Users' Association (Incorporated) is again making representations to the Coal Controller in favour of withdrawal of the present restrictions upon supplies of Welsh steam coal in many parts of the country. Owners of steam wagons are finding they cannot discharge their transport obligations, with the result that congestion of dock quays and railway yards is increasing, whilst the drivers and stokers are complaining of the great additional labour, occasioned by the dirty state of the boilers when coal other than "Welsh steam" is consumed.

INDUSTRIAL NOTES.

THE sittings of the Coal Commission were resumed on Friday last, the 13th inst., and after evidence had been given on housing, Sir Richard Redmayne stated that the question of barriers was of sufficient importance to warrant a change of ownership. The loss of coal, he added, amounted to tens of thousands of tons upon that score alone. In regard to the lack of mining tubs, Mr. H. Smith stated that of 170 miners' lodges who had been questioned in the matter, 138 replied; of these, 85 said they had not been supplied with a sufficient number of tubs, which fact was admitted in 60 per cent. of the cases by the employers and in 10 cases by the managers. Sir Richard, in this connection, put in a letter stating that 200 tubs had been ordered from one firm who could not carry out the order, their workpeople having struck.

Mr. Birtles, Registrar of Joint Stock Companies, said that the number of shareholders, 37,000, mentioned in the course of the inquiry, only related to shareholders in coal-mining, the number was 132,000 including shareholders in allied industries.

On the following Saturday, the 14th inst., the public sittings concluded, when Sir Richard Redmayne said it was extraordinary at the present day to what a small degree science was brought to bear upon the consumption of coal. We were as a nation extremely ignorant, he added, as to the quality of British coal. He had found, in the time he had been on the Coal Export Committee, that the foreigner had a better knowledge of the quality of British coal than we had.

Mr. Justice Sankey, the chairman, announced that the report of the Commission would to-day be in the hands of the Government.

Speaking on Thursday, the 12th inst., at the thirty-eighth ordinary general meeting of Siemens Brothers and Co., Limited, Mr. G. Mure Ritchie, the chairman, said: ". . . Before the war we were, under the conditions then existing, too insular in our policy; now as a purely British industrial concern we aspire to a substantial share of that world-wide expansion which great firms seek, and in this connection last year, with the approval of the British authorities, we despatched on a tour round the world two gentlemen of standing and experience, Messrs. Hopkins and Leonard, the latter being an old official of the company who had extensive experience in our export department. We did not charge them to book orders for the company's products, that being left to the company's various local agents abroad, but our ambassadors were instructed to make it plain, and have made it plain to all, that the ownership of Siemens Brothers and of the Dynamo Company has passed from the hands of a German company into those of a British company, and that while continuing to carry on the traditions of sound material and good workmanship long associated with Woolwich and Stafford, we are no longer under German influence or working for German interests. Our representatives, after having visited the more important States of South America, went to the Cape, from the Cape to India, Singapore, and China. They are now in Japan, and thence will go to Australia and New Zealand, returning to Britain by the United States and Canada. I am pleased to say," added Mr. Mure Ritchie, "that they have been everywhere received with cordiality and that we have evidence from official and authoritative sources abroad and in our overseas Dominions that their conferences have been highly appreciated. In pursuance of this larger policy we recently negotiated and completed an agreement with a very important agency, which will now act as our representatives in China for the majority of our products and those of the Dynamo Company . . . ."

The Labour Gazette for the 18th inst. says there was an improvement in the state of employment during May, and the out-of-work donation statistics showed that the large amount of transitional unemployment which had prevailed in recent months had diminished considerably. The number of unemployed persons whose out-of-work donation policies remained lodged at Employment Exchanges fell from 1,093,328 at April 25 to 771,211 at May 30—a reduction of 322,117. The number of policies lodged by women (civilians) and girls fell from 472,905 to 221,128, *i.e.*, by 251,777, this accounting for 78 per cent. of the total reduction.

After making allowance for the reduction in the number of policies lodged owing to the exclusion of policies of persons working short time, to the abandonment of claims to extended donation on the expiry of the first period of 13 weeks, and to the review of policies, there is no doubt that the substantial decrease since April 25 is to a considerable extent the result of an improvement in the state of employment. This improvement is confirmed by the trade union records of unemployment and by the detailed reports on the separate industries.

Increases in wages which came into operation in May affected nearly 350,000 workpeople, and about 300,000 workpeople were affected by reductions in hours of labour. The general level of retail prices of food and other items entering into the cost of living was about the same on June 2 as at the beginning of May, viz., about 105 per cent. above the pre-war level.

The total number of persons in receipt of unemployment donation at May 30 was 771,211. The composition of this total was as follows: (*a*) Civilians—Men 150,250, boys 12,912, women 207,897, girls 13,231; (*b*) Demobilised—men 384,919, women 2,002. An analysis of the policies lodged at May 30 revealed that 68,444 of the unemployed persons were in receipt of the reduced donation which is paid to civilians after the expiry of the first period of 13 weeks' unemployment.

The number of men on the live registers of the Employment Exchanges at June 6 was 569,098, or a decrease of 84,172 on May 9 and the number of women was 256,038, or a decrease of 194,117 on the total at May 9. The number of vacancies unfilled on June 6 was 45,311 for men and 59,751 for women, the corresponding figures for May 9 being 44,211 and 62,369.

Trade unions with a net membership of 1,337,759, excluding those serving with the Forces, reported 2·1 per cent. of their members as unemployed at the end of May, as compared with 2·7 per cent. at the end of April, and 0·9 per cent. a year ago.

The number of workpeople employed at coal mines included in the returns for the week ended May 24 was 1 per cent. greater than in the week ended May 3, and 18 per cent. greater than a year ago. The average number of days during which the collieries were working was nearly 5½ days per week, a figure which compares with an average of 5½ days in May in the fifteen years 1900–14. At iron and shale mines employment continued good, and at lead and tin mines it was fairly good generally. At quarries it was good on the whole, and operations were favourably affected by fine weather.

In the pig-iron industry employment remained good. At iron and steel works it continued good on the whole and was slightly better than in April and about the same as a year ago. There was little change on the whole in the engineering trade during May, but the district reports varied considerably. In the shipbuilding trade employment remained good on the whole. With tin-plate workers it continued good, and was much better than a year ago, the number of mills in operation showing an increase of 40 per cent. as compared with May, 1918. In other metal trades employment was fairly good on the whole.

The brick trade continued to improve, employment being good or very good in the most important centres. Cement workers continued to be well employed, and worked much overtime. In the pottery and glass trades employment continued good, with a shortage of skilled men. In the building trade there was a slight general improvement and employment, taken as a whole, was fair.

Dock and riverside labourers continued to be fairly well employed on the whole; the supply of seamen was still equal to or in excess of the demand.

The changes in rates of wages (including war bonuses) reported to the department as having come into operation in May resulted in an increase of over 80,000*l.* in the weekly wages of nearly 350,000 workpeople. The principal changes affected workpeople employed in the wholesale clothing and bespoke tailoring trades, and those engaged in the production of leather. Numerous changes also took place in the wages of workpeople in the building, printing, and bookbinding trades. The changes in hours of labour during May affected about 300,000 workpeople, whose recognised working week was reduced by about 8 hours.

The forty-seventh annual report, for the year 1918, of the United Patternmakers' Association, states that the total funds of the association stand at 157,574*l.*, equal to over 15*l.* per member; or taking general funds alone, 109,633*l.*, equal to over 10*l.* 10*s.* per member.

A pamphlet written by Mr. H. G. Williams, secretary and general manager of the Machine Tool Trades Association, on "The Nation's Income," contains a large amount of interesting figures and statements, from which we take the following brief abstract:—

The total population of the United Kingdom in 1894 was 38,860,000, and the average income of all persons was 37·85*l.* The total population in 1913 was 46,030,000, and the average works out at 49·9*l.*, worth 41·25*l.* in 1894 values, so that the increase in purchasing power of each person increased on the average by 9 per cent. An increase of 9 per cent. in nineteen years is a poor result, being less than ½ per cent. per annum.

Increased prosperity can only arise from increased production, and the nation in quarrelling about the division of the product has failed to produce enough of the product.

The year 1907 marked a definite change in the political tendency in this country, and since that time much of our legislation was inspired by the Labour Party. It is, therefore, interesting to work out the figure for that year, one in which there was a boom in trade, as in 1913, and to compare it with the figures for 1894 and 1913.

The index number of retail prices was 105, showing a rise of 10·6 per cent. as compared with 1894. The population was 43,737,000, and the average income works out at 45·85*l.*, worth 41·5*l.* in the values of 1894. This shows that between 1894 and 1907 there was an improvement of 9½ per cent., while between 1907 and 1913 there was a setback of ½ per cent.

In a pamphlet dealing with the coal industry, Mr. Harold Cox, editor of *The Edinburgh Review*, says that the demand for nationalisation is in no way the outcome of present conditions of service in the mines. The Nationalisation of Mines and Minerals Bill was adopted by the Miners' Federation of Great Britain as far back as October, 1912. The demand springs from a theoretical preconception in favour of nationalisation as an ideal solution of social problems.

In 1886, states Mr. Cox, the Trade Union Congress meeting at Hull unanimously passed the following resolution: "That, in the opinion of this Congress, the royalty rents and other charges demanded by the landlords of this country are iniquitous and injurious; iniquitous, because they form a monopoly of our mineral resources, where they should be used for the good of all; injurious, because they place a tax upon our staple industries, interfering with and hindering our commercial prosperity, restricting the profits of the capitalist, and limiting the already too small wages of the workman." In 1886, the representatives of labour were apparently anxious to secure larger profits for the capitalist as well as larger wages for the workpeople. This resolution, adds Mr. Cox, was quoted with approval in the House of Commons in 1894, by Mr. Woods, a miners' representative, in bringing forward a motion in favour of the abolition of royalties. Mr. Woods and his supporters disregarded the fact that a Royal Commission, which had been sitting for three years and included prominent miners' leaders, had reported unanimously that mining royalties were not injurious to the mining industry and only required subsidiary amendments. The words of the Commission's report are as follow: "We are of opinion that the system of royalties has not interfered with the general development of the mineral resources of the United Kingdom or with the export trade in coal with foreign countries. We do not consider that the terms and conditions under which these payments are made are, generally speaking, such as to require interference by legislation." This report was presented in 1893; it was signed by Mr. Thomas Burt and Mr. William Abraham as well as by all the other members of the Commission after an exhaustive inquiry extending over 2½ years.

The royalties and wayleaves now paid to private owners amount to less than 7,000,000*l.* a year. They are subject to income-tax, to mineral rights duty, to excess mineral rights duty, and in many cases to supertax; in Scotland, they are subject also to local rates. After the State and the local authorities have taken their share of the existing royalties, the sum remaining to the owners represents very little more than 1*s.* a week on the wages of the workers. The interim Sankey Report has awarded the workers an increased wage of 2*s.* a day, which is being provided out of the public exchequer. The nation will not get cheap coal either by confiscating existing royalties or by appropriating future royalties.

The pamphlet from which we quote gives interesting information on the telegraph losses, the telephone failure, &c., and points out the dangers of nationalisation.

TRADE WITH BRAZIL.—The Brazilian Commercial Delegates who are shortly to tour the commercial centres of Great Britain under the auspices of the Federation of British Industries are expected to arrive in this country before the end of the present month. They include Dr. Pandia Calogeras, the ex-Minister of Finance, Agriculture and Commerce, and other eminent Brazilians. Members of the Federation of British Industries attached to the tour are Mr. Guy Locock, C.M.G., Brigadier-General A. H. Leggett, C.M.G., Mr. Edmund L. Hill (general secretary) and others; the Reception Committee consisting of Sir Maurice de Bunsen, Sir Richard Vassar-Smith, Bart., Sir Vincent Caillard, Mr. Philip Lockhart, and Mr. R. T. Nugent. The delegates, after a few days' stay in London will proceed, first to Birmingham, then to Glasgow, Edinburgh, Newcastle-on-Tyne, Darlington, Liverpool, Manchester, Sheffield, Leeds, Leicester, Bristol, Swansea, returning to London about the middle of August. Arrangements have been made for them to visit important works in the different cities above mentioned.

THE DIESEL ENGINE USERS' ASSOCIATION.

At the last meeting of the Diesel Engine Users' Association, the subject of insurance of Diesel and semi-Diesel engines against breakdown occupied the attention of the members. Some time back the association, after careful consideration, had adopted a standard form of policy of insurance against breakdown. One of the conditions adopted provides that in the event of disagreement of the interpretation of the policy, the matter shall be submitted for arbitration between the assured and the underwriters to a special committee of the Diesel Engine Users' Association, whose decision is to be final and binding on both parties. A case in which a dispute had arisen was reported to the meeting, and a special committee to deal with this matter was appointed.

The association proposes to take action in regard to carrying out research work with a view to obtaining more definite information as to the suitability of various classes of liquid fuels for use in Diesel and semi-Diesel engines, or for other purposes, and it was decided to make application for a Government grant in aid of this work.

A discussion took place on the report made at the previous meeting by Mr. G. W. F. Horner, on the breakdown which had occurred on a Diesel engine at Weymouth. Apparently the trouble had been caused by the fracture of a connecting rod big-end bolt. In this connection varying opinions were expressed on the subject of fixing a useful life for such bolts before renewal, and the opinion of various speakers as to a proper limit to allow for the useful life of such bolts varied between 5,000 and 20,000 working hours. The question of the efficacy of heat treatment or annealing of bolts of various classes of steel was also discussed, and in connection with heat treatment the Wild-Barfield type of automatic electric furnace was mentioned and briefly described. A desire was expressed by several speakers for the collection of more definite information as to the practice adopted by various makers and engine users in connection with the renewal of connecting rod bolts or of the adoption of any system of annealing or heat treatment, and if so, what period of working hours was allowed before annealing, and whether such annealing or heat treatment could be satisfactorily repeated several times. It was understood that the honorary secretary would endeavour to obtain such information from various sources with a view to the ultimate adoption of some general rule or recommendation by the association. Engine manufacturers, engine users or companies interested in insurance of engines against breakdown, who may be interested in this matter, are invited to communicate with Mr. Percy Still, Honorary Secretary of the Association, at 19, Cadogan Gardens, S.W. 3. The president, Mr. Napier Prentice, announced that at the following meeting of the association, Mr. George E. Windeler would explain a method of checking the alignment of shafts, and a means of proving whether a shaft was bedding in its bearings.

ROYAL METEOROLOGICAL SOCIETY.

The usual monthly meeting of this society was held on Wednesday, the 18th inst., at the Society's Rooms, 70, Victoria-street, Westminster, Sir Napier Shaw, F.R.S., president, in the chair. A paper by Colonel Sir Charles Close, K.B.E., F.R.S., entitled "*Note on the Rainfall at Southampton and London during a Period of Fifty-Seven Years* (1862–1918)," was read. The variations in rainfall in England are so great that any seasonal period can only be detected by the study of many years' statistics. Even when the statistics are available for a long period, the form in which they are usually published does not readily lend itself to a clear appreciation of the existence of a simple seasonal period. Thus, the monthly means are usually uncorrected for variation in the lengths of the months, and the custom of treating the months separately produces an effect of discontinuity. If, however, after correcting for monthly inequalities, the accumulation of rainfall, reckoning from any fixed date, is tabulated and plotted, the rainfall assumes a more regular aspect. If, further, from these monthly figures of accumulation we deduct the average precipitation the remaining figures approximate to a simple sine curve, with an annual period. The irregularities left over occur chiefly in September and October. The fifty-seven years' rainfall at Southampton, from 1862–1918, have been examined in this way, and the London rainfall for the same period. For Southampton, counting from April 1 (but any date will do), the accumulation, in inches at n months, is represented by the expression:

$$2{\cdot}63 \times n - 0{\cdot}95 - 1{\cdot}35 \sin (n \times 30 \text{ deg.} - 45 \text{ deg.})$$

For London, by the expression:

$$2{\cdot}13\, n \times 0{\cdot}7 \sin (n \times 30 \text{ deg.})$$

The maximum irregularities left over amount to:

0·30 in. and 0·20 in., respectively, on October 1.

It would appear, then, that at the places in question the rainfall can be considered to result from uniform precipitation throughout the year, modified by a simple annual harmonic term, further modified by small irregularities in September and October.

A second paper was a "*Note on Tornadoes*," by Lieutenant J. Logie, R.A.F., F.R.Met.Soc. The paper aimed at showing that no convection currents are capable of producing tornadoes of the intensity claimed for some of these storms. Working from the equation $d\,p/d\,h = -g\,D$ (which is shown to be sufficiently accurate for the purpose in hand, even in a tornado centre) and assuming that at some height the pressure above the tornado is equal to that at the same level outside, the author computes the difference of temperature between the air in the centre of the tornado and that outside. For a tornado having a pressure reduction of 50 millibars at the surface the mean temperature difference is found to be 23 deg. A. if the tornado extends only to 5 km. (16,000 ft.), 10 deg. A. if it extends to 10 km., and 5 deg. A. if it extends to 15 km. From the known values of the lapse-rate of saturated air it follows that under conditions of maximum instability a saturated ascending current not less than 8 km. high might produce a tornado of this intensity. Since such instability rarely occurs, and, in addition, ascending currents of saturated air are usually everywhere penetrated by descending masses of cooler air, even a tornado of this intensity is unlikely to be so produced in natural conditions. The case of a 250 millibar reduction is also considered, as being at times actually achieved. In this case the temperature difference, even if the tornado reaches 15 km., is shown to exceed 35 deg. A., a difference not capable of being produced by the release of latent heat due to condensation of cloud, and still less likely to be caused by simple heating of the ground surface. It is suggested that the required rise of temperature may be due to the lightning which is usually described as a characteristic of the funnel cloud.

A third paper was read by Captain D. Brunt, R.E., F.R.Met.Soc., entitled "*A Periodogram Analysis of the Greenwich Temperature Records.*" The monthly mean temperature at Greenwich for the years 1841 to 1890 were taken and represented by a Fourier series up to 100 terms, so as to permit of the detection of any periods of length greater than one year. Periods of 9·5 years, 5 years, 4 years, 23 months, and 20 months were shown to exist, all having amplitudes of the order of 0·5 deg. F. Some of these correspond to periods found in other meteorological records, *e.g.*, the twenty-month period has been found by Professor Turner in the rainfall records of Greenwich and Padua. The interval covered by the observations was insufficient to permit a detailed discussion of periods of length greater than about ten years. Many of the periods found were not continuous during the whole interval covered by the observations, *e.g.*, the twenty-month period died away about 1894, being replaced by a period of about twenty-three months. The general result of the investigation was to show that periods in astronomical sense do not exist in these temperature records. It was shown that the effect of correcting the observations for the effect of the periods found was to produce an almost inappreciable diminution of the standard deviation of the observations, tending to show that the variations of the monthly mean temperatures from year to year are to be regarded either as purely chance variations or as due to periods of length less than a year.

A fourth paper presented was "*On the Propagation of Sound in the Atmosphere*," by Lieutenant G. Green, R.E. Sound waves emitted by a source situated on the earth's surface generally undergo refraction as they advance owing to the changing conditions of wind velocity and of temperature as the waves pass from layer to layer of the atmosphere. In the paper, a mathematical discussion is given of the paths of sound rays issuing in all directions from a source, under certain conditions of wind velocity and temperature closely resembling the conditions generally to be observed in the atmosphere. The mathematical results obtained would make it possible to calculate the mean speed of sound in any chosen direction from a source to a recording instrument at a given distance from it, provided observations of the horizontal velocity of the wind and of the mean temperature of the air have been taken, at the earth's surface, and at various heights above the surface. The mean horizontal velocity of a sound element in tracing out a ray is equal to the sum of the velocity of sound and the horizontal component of wind velocity in the plane of the ray, taken at a height above the earth's surface equal to one-third the total height reached by the ray. Numerical results are given for special cases to illustrate the effect of a given wind gradient on the propagation of sound in all directions from a source; and the effect of the same wind gradient combined with a favourable and also an unfavourable temperature gradient. The case of a wind increasing in velocity and veering as we ascend from the earth's surface is illustrated in the closing section of the paper.

IMPORTS INTO FRANCE AND ALGERIA.—*The Board of Trade Journal* for the 19th inst. contains preliminary particulars of the French Presidential Decrees published in the *Journal Officiel*, providing for the abolition of import restrictions on a large number of goods imported into France and Algeria, and the increase, by means of *ad valorem* surtaxes, of the rates of customs duty upon goods imported into those countries. Copies of the Decrees in question are on view at the offices of the Department of Overseas Trade, 73, Basinghall-street, E.C. 2, and the full translation will be published in the issue of *The Board of Trade Journal* for the 26th inst.

A GERMAN NITROGEN SYNDICATE.—A nitrogen syndicate has now been formed in Germany, the Legislature not viewing with favour the contemplated trading monopoly for nitrogen. The syndicate, which has been formed under the auspices of the Exchequer, comprises all producers of nitrogen (ammonia from coal and also atmospheric nitrogen) in Germany. As the German Exchequer has invested large sums in the nitrogen works, it has secured a leading position in the syndicate and has thus secured a voice in the regulation of the prices. It is also proposed to form a combine of the consumers.

THE STILL ENGINE.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the correspondence in your issue of the 13th inst., I will not undertake the somewhat formidable task of correcting Mr. Leigh Martineau's letter *in toto*, but his lament about my failure to push my investigations further is wasted, because as a matter of fact that is exactly what I did. Let me restate my point, taking as a basis the figures given in Captain Acland's paper.

One-half of the total heat of combustion is by one means or another imparted to the steam. This is the reclaimed waste heat. What becomes of it according to Captain Acland? 18 per cent. reappears as work in the steam cylinder, 82 per cent. is again thrown away—74 per cent. in the condenser and 8 per cent. in radiation. Four-fifths of what has been laboriously reclaimed from the wastepaper basket is thrown into the dustbin. To salve the odd fifth, it has been necessary to add many of the troubles of the steam engine to those of the internal-combustion engine.

If we take the figures given by Mr. Leigh Martineau in his letter of the 7th inst., we find the same thing again. Of the total heat imparted to the steam, 14 per cent. appears as useful work in the engine, and no less than 86 per cent. appears again as waste.

I hope that many others who are "truly British in thought" will agree that this result should not be accepted as a final and satisfactory one.

I do not suggest for one moment that my experimental work was on the same scale as Mr. Still's. If it gives Mr. Leigh Martineau any satisfaction, I willingly concede that I have often made mistakes, and that Mr. Still's researches have been far more extensive, elaborate and accurate than mine, but the fact remains that he has reached the same result, and his experiments show that only a small fraction of the heat imparted to the steam can be made to serve any useful purpose at all, and a very considerable increase in the complexity of the plant is necessary to achieve even this result. Nor can there be any substantial improvement which is not at the same time an improvement to the steam engine—already a formidable rival.

Let Mr. Leigh Martineau keep to the point I have raised without worrying about my grandfather or the history of air navigation. I repeat that the real snag lies in the latent heat of evaporation of water. Can he, or can he not, see any hope of bringing the condenser losses down from the present figure of 80 per cent. or 85 per cent. to a more reasonable figure, say, 25 per cent. or 30 per cent.?

As it stands, the real question is whether the saving which can be effected in a combined steam and internal-combustion engine, taken together with the other advantages, reversibility and so forth, is worth the extra complication, or whether it is not. Each one of us will give his own answer, depending on his individual knowledge and experience.

Yours faithfully,

CHARLES W. KAY.

Fairoak, Elm-road, Woking, June 18, 1919.

DRAUGHTSMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—When Mr. Walker first wrote of the "democratic" methods of the A.E.S.D. and assured us that "on vital matters a referendum is taken" I ventured to put several specific questions to him and to remark that when we had his answers we would be able to appreciate his statements at their proper value. To take the four cases I cited, upon two of them, viz., affiliation to the Trades Union Congress and the increase of the annual subscription, no referendum was taken *because the Representative Council did not see fit to do so.* On the matter of affiliation to the Labour Party, again no referendum was taken, but we are assured by Mr. Walker that a ballot would have been a legal necessity. For this relief much thanks, but why make such a virtue of necessity? The last case I gave was the subscription to the Labour Research Department which, not to put too fine an edge on matters, was the perversion of the association's funds to political purposes. On this point the members were not consulted at all! To use a most expressive vulgarism, Mr. Walker's reference to democratic methods and the referendum is just so much eyewash and means exactly nothing.

In conclusion, Sir, allow me to thank you for the hospitality of your columns and to join in the appeal made by "O.L.D." to all members of the A.E.S.D. to turn out to the meetings of the various branches so as to ensure that the association will not be run by a small minority of political extremists whose perseverance and energy are worthy of a better cause.

Yours sincerely,

"SCRUTATOR."

AMERICAN BUSINESS WITH JAVA.—It is reported in *The Iron Age* that American machinery, the sale of which was greatly increased in Java and the neighbouring islands by the war, will be still more in demand, according to Mr. K. F. Van der Berg, special commissioner for the Government of the Dutch East Indies, who is now in New York to bring about closer commercial and financial relationships between the United States and the Dutch East Indies. Iron and steel products, he said, now constitute the principal items which are imported by the East Indies; there is every indication, he added, that this demand, which already constitutes one-quarter of the entire imports, will be greatly increased, and that American machinery and metals will be especially in request, now that the people of the islands are learning more about them.

WELDING MILD STEEL.*

By H. M. HOBART,† New York, N.Y.

(*Concluded from page* 786.)

19. *Suitable Current for Given Cases.*—For a given type of weld, for example, a double vee-weld in a ½-in. thick ship plate, it was found that while some operators employ as low as 100 amperes, others work with over 150 amperes. Some, in making such a weld, employ electrodes of only ¼ in. diameter, and others prefer electrodes of twice as great cross-section. For the particular size and design of weld above mentioned, the Welding Research Sub-Committee has had welds made with from 200 amperes to 300 amperes. The conclusion appears justified that the preferable current for such a weld is at least 200 amperes. If the weld of the ½-in. thick plate is of the double-bevel type, some 50 amperes less current should be used for the bottom layer than is used for the second layer, if two layers are used. For ¾-in. thick plates, the most suitable welding current is some 300 amperes. This is of the order of twice the current heretofore most usually employed for such a weld.

Mr. Wagner writes: "We have made a number of tests to determine the effect of varying current on the strength of the weld. Tests were made on a ½-in. plate with current values as follows: 80, 125, 150, 180, 220, 275 and 300 amperes. These tests show improvement in the tensile strength and bending qualities of welds as the current increases. The speed of welding increases up to a certain point, and then decreases."

20. *Effect on Arc Welding of Voltage Employed.*—Mr. Wagner reports as follows: "We have made a number of tests to determine the influence of variable voltages on the strength and character of electric welds. The experiments were made, welding ½-in. plate with 150 amperes held constant, and voltage varying as follows: 40, 75, 100, 125, 150, 200 and 225 volts.

"This test demonstrates that there is no material difference in the tensile strength, bending qualities or the appearance of the welded-in material. There is this advantage, however, in the higher voltage, that variations in the strength of the arc do not materially affect the value of the current. A curve-drawing ammeter was installed on the welding circuit, which showed variations in current at 75 volts, but at 150 volts the current curve was practically a straight line."

21. *Preferable Size of Electrode.*—On certain railways, a single diameter of electrode is employed independently of the size or shape of the plates or parts being welded. The experience of other people leads them to make use of several different sizes of electrodes according to the size of the job and the type of joint. Present British practice appears to be to use such a size of electrode as to have a current density of some 4,000 amperes to 6,000 amperes per square inch. The investigations of the Welding Research Sub-Committee are indicating that at least 10,000 amperes to 12,000 amperes per square inch is suitable for electrodes of ⅛ in. and $\frac{5}{32}$ in. diameter, and well up toward 10,000 amperes per square inch for electrodes of $\frac{5}{32}$ in. and ¼ in. diameter.

22. *Automatic Machinery for Arc Welding.*—Several firms are developing machinery for feeding the electrode automatically. Such machinery appears to be capable of making excellent welds at higher speeds than are attainable by hand feeding.

23. *Carbon-Arc Welding.*—With the advent of metal-arc welding there has been a tendency to neglect the carbon-arc method. It is quite possible that this attitude is not justified, for not only is there now a definite field where the carbon-arc method is advantageous, but developments in the art may greatly extend its application.

It is generally agreed that the carbon-arc method is not applicable to vertical and overhead welding, which is, of course, a serious handicap in ship-hull work. The majority opinion of competent observers (with, however, some emphatic dissenting views) appears to indicate that carbon-arc welding is not as reliable as metal-arc welding in ordinary welding, because:—

(*a*) Carbon is carried into the deposited material, thus reducing its ductility.

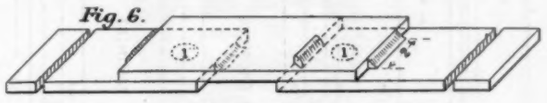
(*b*) It is more difficult to obtain good fusion on account of overlapping of deposited metal on the original metal.

(*c*) It is more difficult to manipulate and thus requires greater skill.

(*d*) It is a much hotter arc, which means greater discomfort to the operator and therefore lower efficiency.

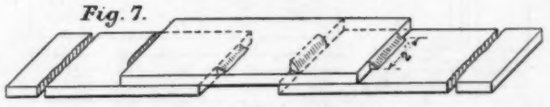
(*e*) Greater cooling stresses are developed because larger areas of adjacent metal are heated.

Fig. 6.



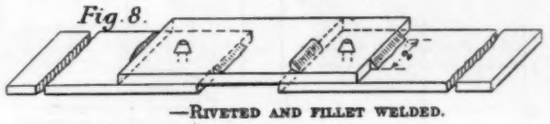
—FILLET AND SPOT WELDED.

Fig. 7.



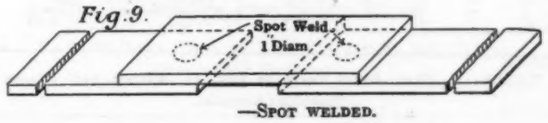
—FILLET WELDED.

Fig. 8.



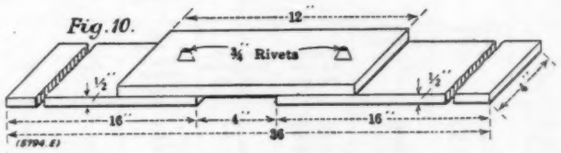
—RIVETED AND FILLET WELDED.

Fig. 9.



—SPOT WELDED.

Fig. 10.



On the other hand, it is contended by some that carbon-arc welding can be developed to the point where these objections will no longer exist, and thus gain the advantages of this method, the principles of which are:—

(*a*) No preparation of the abutting edges is necessary.

(*b*) Greater rate of deposition of metal and therefore greater speed of welding, particularly in heavy work.

(*c*) Probable greater adaptability to automatic welding.

It should be stated that there is very general agreement as to the superiority of the carbon arc over the metal arc for heavy work where strength is not so important, especially cast-iron welding and the filling of holes in iron and steel castings.

24. *Preparation of Welding Edges.*—British practice permits the use of smaller angles when the edges of the plates are veed, than accords with American traditions. If the smaller angles give welds which are equally satisfactory in all respects, the decreased amount of electrode material required, the decreased consumption of electricity, and the increased speed are advantages not to be overlooked; but obviously the matter requires careful investigation. American practice, which, up to recently, has been with a very wide angle, appears to have required the consumption of about twice as great a weight of electrode as British practice with the smaller angle. The urgent importance of determining whether the use of the smaller angle involves any sacrifice in quality is evident. There is already considerable basis for the belief that actually better results attend the employment of a smaller angle of bevel when a suitably large current is used. A shoulder in place of the heretofore commonly used sharp bottom edge of the bevel, also constitutes a material gain not only in the saving in welding material, but also in the quality of the weld.

Mr. Wagner states that at the Pittsfield works of the General Electric Company they have long adopted the practice of using a 30-deg. bevel for plate edgings, and that they find it satisfactory for all thicknesses up to ¾ in. He states that this angle gives sufficient room for depositing the metal, reduces the time to weld and the amount of metal deposited.

In one of Mr. Spraragen's researches, various angles of bevel were used. Although the physical tests have not yet been made, we can gain from the following Table III valuable lessons on the time, amount of metal, and electricity consumed for these different angles of bevel. The "free distance" in each case was ⅛ in., and the welding was done in a flat position with $\frac{5}{32}$ in. bare electrodes. In each case the weld had a length of 3 ft.

25. *Quality of Overhead Arc Welding.*—The British Admiralty regards overhead welding as too inferior and too expensive to be employed when it can possibly be avoided. In America a large amount of overhead welding is done in railway shops, and it is claimed that it is simply a matter of training operators to the required degree of proficiency.

26. *Number of Layers to be Employed.*—Good progress is being made in obtaining knowledge of the relative characteristics of welds made with different number of layers and of the most suitable current and the most suitable size and type of electrodes to employ for each layer. The tendency is toward the use of at least two layers for ½-in. thick plates, and three layers for ¾-in. thick plate.

TABLE III.—*Time, Metal and Current used with Welds of Different Bevels.*

	Angle of Bevel used, in Degrees.			
	15	30	45	60
Amperes	160·00	145·00	118·00	168·00
Weight of electrode used up (lb.)	2·56	3·83	4·63	6·83
Weight of metal deposited (lb.)	1·70	2·55	3·65	5·08
Weight of metal wasted (lb.)	0·86	1·28	0·98	1·55
Pounds deposited per hour	1·82	1·61	1·82	1·81
Feet welded per hour	3·22	1·90	1·50	1·07
Circuit kilowatts	0·91	0·00	7·68	8·25
Kilowatt-hours per foot of weld	3·10	4·70	5·10	7·70

27. *Rigid versus Non-Rigid Methods of Welding.*—On this question it is more a matter of determining the conditions essential to obtaining good results with whichever of the two methods is most appropriate for each particular purpose.

The term rigid is applied to the process of arc welding, in which the two parts to be joined by welding are, prior to welding, held rigidly by bolting or clamping, or by a series of preliminary tack-welds distributed at various points. The rigid plan is the most obvious for welding the hull plates of ships, but its critics claim that the resultant joints are deficient in ductility due to the presence of internal stresses. It is considered that by suitably arranging the order of welding it is practicable to so distribute the heat as to avoid these stresses. At any rate there are many alternative orders of procedure in making welds by the rigid method, and elaborate researches should be made to ascertain the procedure which will yield the best result.

The non-rigid method consists in placing at a slight angle to each other the two plates to be welded. As the welding operation progresses along the seam the angle gradually closes, and when the weld is completed the width of the welded seam is equal throughout its extent. Such welds are generally considered to be very free from internal stresses, and hence more ductile.

28. *Consequences of Different Lengths of Arc.*—The metal arc is much shorter than the carbon arc. As a result the metal-arc weld has the advantage that there is less opportunity for oxygen and nitrogen to gain access to the weld, and so far as relates to this feature the metal arc weld should be better. But with the carbon arc the added metal does not traverse the arc, the tip of the welding rod being held down close to the surface on which it is to be deposited. This may render the deposited material less subject to contamination in carbon-arc welding than in metal-arc welding, since it has not traversed the arc.

Coming to the exclusive consideration of metal-arc welding, the greater the welding current the less is the area represented by the cylindrical surface of the arc per pound of metal traversing the arc, and consequently the less should be the contamination by oxygen and nitrogen from the surrounding air. So far as this circumstance is concerned, the greater the welding current, for a given case, the greater should be the ductility of the joint. On the other hand, it seems probable that even the most skilful operators will be unable to hold quite so short an arc with the larger current.

29. *Spot and Arc Welding.*—A good deal of progress is being made in America in the use of spot welding for the joining of thick plates. It is believed that spot welding has a great future as applied to shipbuilding, and several large spot welders have been built for shipyards. In some of its applications, spot welding affords a method of preliminarily joining the hull plates, after which the required additional strength is provided by arc welding. The Welding Research Sub-Committee has already made some progress in comparing combined spot and arc welds and combined rivet and arc welds with riveted, spot-welded and arc-welded joints. It is not a question in such an investigation of spot *versus* arc welding, but of spot and arc welding. In the tests mentioned, the specimens were made up of the following combinations:—

* Report of research under the joint auspices of the United States National Research Council and the Emergency Fleet Corporation.

† Chairman, Welding Research Sub-Committee.

1. Spot and fillet welded (Fig. 6) (two samples made).
2. Fillet welded—made by welding fillets about 2 in. in length at the ends of the plates (Fig. 7) (two samples made).
3. Riveted and filled welded (Fig. 8) (one sample made).
4. Spot welded—made by welding two spots approximately 1 in. in diameter, on the plates (Fig. 9) (two samples made).
5. Riveted joint, made by riveting a ½-in. by 4-in. by 12-in. plate with two plates ½ in. by 4 in. by 16 in., using two ¾-in. rivets and a 4-in. lap. (Fig. 10) (one sample made.)

The results of the test show the comparative strength of the joints as follows :—

	Lb.
Spot and fillet welded—ultimate load	*50,350
Fillet welded—ultimate load ...	*37,000
Riveted and fillet welded—ultimate load	†35,000
Spot welded—ultimate load ...	*28,000
Riveted joint—ultimate load ...	†13,000

* Average of tests on two samples.
† Only one sample made.

Spot welds, as compared with arc-welded butt joints, have the disadvantage of the increased weight corresponding to the overlap.

30. *Condition of Surfaces to be Welded.*—While for spot welding the surfaces may sometimes be too clean to obtain the best weld, this cannot be the case with fusion welding. The question of the extent to which it is practicable to go in freeing the surfaces from impurities prior to making the fusion weld is entirely a commercial one. The cleaner the surface, the better the weld. In spot welding it is desirable to have clean surfaces under the electrodes, but scale between the two plates is a positive advantage.

31. *Pre-heating and Heat Treatment and Hammering while Cooling.*—Pre-heating, heat treatment and hammering, as applied to fusion welding (both gas and electric) have been the subjects of research, but as yet nothing adequately comprehensive has been planned. It is very important that these deficiencies should be recognised and remedied.

32. *Time Required to Train Welders.*—As to the training of welders, there are on the one hand those who are so ill-informed as to assert that good welding can be done after a very few weeks of training, while on the other hand, others assert that an operator can hardly acquire any considerable degree of skill in much less than a year. Still others advocate the substitution of automatic feeds and the complete elimination of dependence upon manual dexterity. For arc-welding work requiring more than 100 amperes this is, in the author's opinion, not a trade for women when the arc is manipulated by hand as distinguished from the use of automatic or semi-automatic machinery.

33. *Question of Need for Special Machines for Welding.*—A great variety of machinery for supplying and controlling the current for welding is on the market. Some of this machinery comprises elaborate mechanisms in virtue of which it is claimed that it would be very difficult for even a novice to make a bad weld. Some advocate the use of simple resistance to be inserted in series with the arc on any available circuit, and claim that any additional machinery is superfluous. The capital outlay for the equipment of a welder (at the point of consumption) when the first kind of equipment is used, may be a matter of over 1,000 dols., while in the second case, well below half of the sum is sufficient.

34. *Technique of Testing Welds.*—The ideal weld should presumably be at least as strong and as durable as the metal of the members joined together. In other words, the section containing the weld should have the same chemical and physical characteristics as adjacent sections in the original metal. A weld is therefore measured by the degree of approximation to this condition as determined by mechanical, chemical and metallurgical tests of :—

(*a*) The parent metal.
(*b*) The welded joint.
(*c*) The deposited material in the weld.

While during the last year the Welding Research Sub-Committee has made a great deal of progress in establishing standard procedures for the mechanical testing of welds, much still remains to be done. Obviously, the procedure for testing the original metal should follow standard practice as recommended by the American Society for Testing Materials, but there is considerable difference of opinion and uncertainty as just how and what mechanical tests should be made of the welded joint and of the deposited metal. For instance :—

(*a*) Should all the usual observations be taken when making a tensile test of a welded joint ? Obviously the strength of the union between the two pieces of metal should be determined, but in view of the non-homogeneity of the specimen, does not a very different significance attach to yield-point, elongation and reduction of area ? Where a series of welds having the same ratio of deposited material to original metal is concerned, such data are undoubtedly important for comparison purposes, but for evaluating a weld in terms of the original metal, questions are repeatedly being raised as to just what extent these data have value.

(*b*) Would not more reliable information as to the ductility of the weld be obtained if elongation and reduction of area measurements were made on specimens prepared from the deposited metal, or from specimens cut lengthwise of the weld instead of crosswise ?

(*c*) Similarly with the bending test, which is a test for ductility. There are some (including the author) who would make the bend with the axis of the mandrel normal to the weld instead of parallel thereto, which latter position is the one usually employed. It may be that both tests should be made ; the normal position as test of the ductility of the deposited material and the parallel position as an additional test of the union between the deposited material and the original metal.

(*d*) How important are torsion tests and impact or shock tests in measuring welded joints ?

(*e*) Fatigue tests of welded joints are generally conceded to be vital and the importance of obtaining reliable information as to how this test should be made probably transcends (at present at least) that attached to any other research in the field of fusion welding. The researches should be made :—

(1) With the Moore bending fatigue machine.
(2) With rod samples rotated at high speed as employed by Lloyd's Register in England.
(3) With the Stromeyer torsion-fatigue machine.
(4) With the Cammell-Laird bending fatigue apparatus.
(5) By the Upton-Lewis test.

After the necessary research work has been done to solve these and other similar questions pertaining to the testing of welds, standard specifications for the testing procedure can be prepared which will be properly balanced between the cost of making the tests and the amount of testing necessary to insure a reliable estimate of the weld.

Conclusion.—The extent of the field of application for fusion welding and spot welding is but little appreciated

Fig. 11.

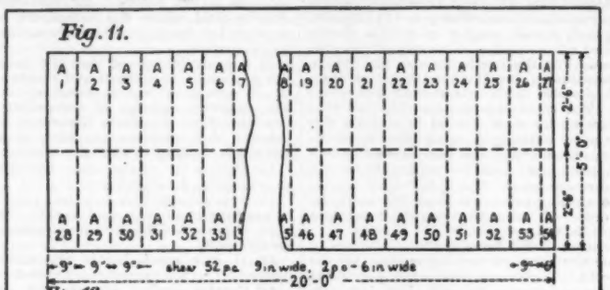


Fig. 12.

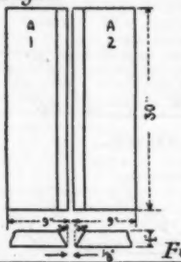


Fig. 13.

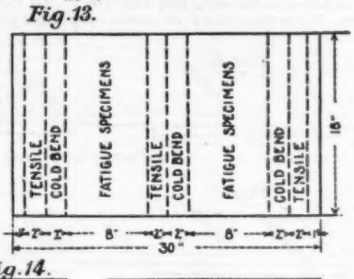
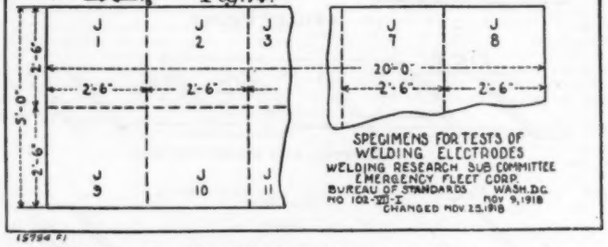


Fig. 14.



(5756 e)

TABLE IV.—WIRT-JONES TESTS OF ½-IN. ARC-WELDED SHIP PLATES.
(Machined Samples).

Test Number.	Current in Amperes. A.C.	Current in Amperes. D.C.	Diameter of Elec. in In.	Current Density, Amperes per Sq. In.	Tensile Tests. Ultimate Lb. per Sq. In.	Tensile Tests. Per Cent. Elongation in 2 In.	Bending Angle at which Crack Starts. Degrees.	Electrode. Cov.	Electrode. Bare.	Electrode. Make.
20	175	—	0·125	14,227	62,700	9·0	34	C	—	E. A. C. and W. Co.
1	—	175	0·166	9,118	59,800	9·0	42	—	B	Roebling.
22	160	—	0·125	13,008	50,000	6·0	78	C	—	E. A. C. and W. Co.
2	—	155	0·156	8,075	62,600	11·5	44	—	B	Roebling.
19	150	—	0·125	12,195	62,800	12·0	32	C	—	Quasi.
31	—	150	0·166	6,930	60,900	8·0	—	—	B	Roebling.
29	—	150	0·156	7,815	56,400	6·5	—	—	B	W. W. and M. Co.
38	150	—	0·156	7,815	54,500	7·0	45	C	—	E. A. C. and W. Co.
29	—	150	0·156	7,815	54,400	6·0	47	—	B	W. W. and M. Co.
9	—	150	0·156	7,815	44,200	4·0	26	—	B	Toncan.
9A	150	—	0·187	5,430	42,500	4·0	30	—	B	Armco.
10	—	150	0·156	7,815	41,900	4·5	25	—	B	Toncan.
10	—	150	0·156	7,815	41,300	4·5	24	—	B	Toncan.
9	—	150	0·156	7,815	38,100	4·0	15	—	B	Toncan.
9A	150	—	0·187	5,430	36,300	4·0	—	—	B	Armco.
5	—	145	0·156	7,554	61,100	8·5	55	—	B	Am. S. and W Co.
25	136	—	0·156	7,085	43,700	3·5	26	—	B	Roebling.
30	—	135	0·156	7,033	53,200	11·0	—	—	B	W. W. and M. Co.
30	—	135	0·156	7,033	52,000	10·5	50	—	B	W. W. and M. Co.
37	125	—	0·125	10,162	56,400	7·0	42	C	—	E. A. C. and W. Co.
7	—	120	0·125	9,756	57,600	8·5	50	—	B	Roebling.
7	—	120	0·125	9,756	53,700	7·0	45	—	B	Roebling.
8	—	115	0·125	9,349	59,400	13·5	60	—	B	Roebling.
8	—	115	0·125	9,349	58,200	14·0	—	—	B	Roebling.
3	—	115	0·156	5,891	50,600	5·0	34	—	B	Am. S. and W. Co.
16	—	110	0·134	7,799	50,250	7·0	35	C	—	Quasi.
27	—	110	0·125	8,943	45,800	8·0	42	—	B	Roebling.
21	105	—	0·134	7,444	42,200	5·0	42	C	—	E. A. C. and W. Co.
26	94	—	0·125	7,642	34,200	3·0	15	—	B	Roebling.
18	90	—	0·134	6,381	54,000	6·0	65	C	—	Quasi.
15	—	90	0·134	6,381	39,400	4·0	30	C	—	Quasi.
24	—	86	0·125	7,154	45,400	6·0	15	—	B	Roebling.
23	—	85	0·125	6,930	51,900	4·0	—	—	B	Roebling.

by engineers other than those who have been directly connected with welding developments. It is evident that this field is an enormous one, including as it does all structures where steel is employed, such as bridges, building structures, tanks of all types and kinds, railway rolling-stock, and ships, in addition to numberless miscellaneous applications in industry in general.

However, engineers associated with welding research should be on their guard that their enthusiasm over this great field of application shall not lead them into prematurely endorsing the use of fusion welding or spot welding in constructions where the consequences of failure involve serious menace to life and property, as may often be the case. For example, a particularly important case is that of pressure vessels and especially large high-pressure containers. The success in 100 installations will not excuse failure (accompanied possibly by fatalities), in the one hundred and first installation. It is the opinion amongst the best informed engineers that before fusion welding can advisedly be employed for large high-pressure vessels, much vigorous and elaborate research work should be carried out on the fatigue characteristics of fusion welds of long seams, and that this research work must comprise full-sized structures, since the conditions cannot be reproduced in test samples.

In fact, if the general acceptance of welding, particularly by inspection boards, underwriters and classification societies, is to be accomplished in a reasonably short time, such extensive research work on a large scale is absolutely essential in order to demonstrate conclusively that welded joints are equal to, or better than, joints made by other methods. Obviously the development of the art could proceed along the lines of the usual order of evolution as in the cases of previous arts, but this would, as in those cases, involve the lapse of years.

For structures subjected to less extreme stresses, such as the hulls of ships, the adequacy of fusion welding as a substitute for riveting is in process of being thoroughly demonstrated in actual practice in Great Britain. It is recognised that the hulls of ocean-going ships are exposed to very great stresses, nevertheless there is a clear distinction between the magnitude of those stresses and the stresses to which many large, high-pressure containers are subjected.

The author hopes this paper will aid in focusing attention on the vast importance of the welding art, particularly by occasioning discussion of the many problems in welding research, some of which have been mentioned in the paper.

The author cannot undertake to give adequate acknowledgment of his indebtedness to his many associates in the preparation of this paper. The most generous assistance has been given him on every hand. Mr. William Spraragen has extended much assistance in preparing data and in many useful ways. Mr. F. M. Farmer, chief engineer of the Electrical Testing Laboratories, has given very generously of his time in advising the author in detail about many points which arose in the course of the preparation of this paper.

Four appendices accompany this paper:—

Appendix A: "Standard Procedure for Testing Welding Electrodes." Appendix B: "The Wirt-Jones Tests of Arc-Welded ½in. Ship Plates." Appendix C: "Bending Tests of Gas Welds." Appendix D: "Arc Welded Steel Box."

APPENDIX A.

STANDARD PROCEDURE FOR TESTING WELDING ELECTRODES. WELDING COMMITTEE, EMERGENCY FLEET CORPORATION, NOVEMBER, 1918.

1. *Purpose.*—The purpose of this specification is to provide a standard procedure for testing welding electrodes for electric-arc welding which are submitted for the information of, and with the view to the approval by, the Welding Committee of the Emergency Fleet Corporation.

Note.—This specification describes a test of electrodes and not a combination of an electrode and of an apparatus. The fact that the applicant is given the option of selecting the system with which the test is made, does not make it a test of that system, any more than the employment of a particular welding operator could be said to make it a test of a welding operator. The system used in making these tests may or may not prove to be of importance. It is sought to minimise the influence of the individuality of the operator by requiring the test to include welds made by at least two operators.

The Welding Committee has two other Sub-Committees into whose province falls the Approving and Certifying of Operators and the Approving and Certifying of Systems. The admission that these three tasks overlap does not involve any reason for delaying the important task of proceeding at once with the standardising of the testing of electrodes.

2. *General Conditions.*—(a) Each applicant shall provide at his factory or elsewhere as he may elect, the necessary facilities and at least two operators for making the test welds prescribed by these specifications. Except when otherwise indicated in these specifications, the applicant shall select the apparatus and other conditions for making test welds which he considers most suitable for his electrodes.

(b) The test welds shall be made in the presence of an authorised representative of the Welding Committee of the Emergency Fleet Corporation who will be empowered to certify as to the compliance with the conditions prescribed in the specifications. Also representatives of "Lloyd's Register of Shipping" and the American Bureau of Shipping shall have the opportunity to witness the making of the test welds.

(c) Until otherwise declared, the authorised representative of the Welding Committee shall be the Electrical Testing Laboratories, 80th-street and East End Avenue, New York, N.Y.

(d) The Welding Committee shall assume charge of the complete test welds and have them tested by the authorised representative in accordance with these specifications.

(e) The authorised representative shall render to the Welding Committee a complete detailed report of each test of an electrode.

(f) The cost of carrying out the prescribed tests shall be borne by the applicant.

3. *Sample Electrodes.*—About 100 lb. of each electrode to be tested, which will be known as the sample, shall be furnished without charge. It shall be accompanied by an affidavit giving the following information:—

(a) The trade name under which the electrode is marked together with certification that all electrodes bearing this trade name, will be substantially the same as the sample submitted.

(b) The manufacturer of the complete electrode.

(c) The location of the factory in which the electrode was made.

(d) The manufacturer of the welding wire.

(e) The location of the mill in which the welding wire was produced.

(f) The chemical analysis of the welding wire

The authorised representative shall retain the remainder of the sample for reference purposes.

4. *Plate Material.*—For these tests ¼ in. ship plate shall be used. This material shall comply with the "Standard Specifications or Structural Steel for Ships," as adopted by the American Society for Testing Materials serial designation A 12–16 (see page 98, A.S.T.M. Standards, 1918).

An abstract of this specification is as follows:—

1. Open-hearth steel.
2. Phosphorus—acid steel, not over 0·06 per cent.
   basic steel, not over 0·04 per cent.
   Sulphur, not over 0·05 per cent.
5. Tensile strength, pounds per square inch, 58,000 to 68,000.
   Yield-point, minimum pounds per square inch, 0·5 tensile strength.
   Elongation in 8 in., minimum per cent., $\frac{1{,}500{,}000}{\text{tensile strength}}$
6. Yield-point by drop of beam method.
7. Cold bend test; no cracking on outside of bent portion when bent 180 deg. around a pin the diameter of which is equal to the thickness of the plate.

5. *Cutting of Plates.*—(a) The method of cutting a plate 5 ft. by 20 ft. into pieces for welding is shown in the accompanying reproduction of drawing No. 102 of the Bureau of Standards.

(b) Each plate shall be given a distinguishing letter, A, B, &c. This letter shall appear upon each piece cut from it.

(c) Pieces shall be plainly marked with the letter and number arranged as shown in the drawing so that the location of the piece in the plate may be determined.

(d) The plates from which tensile, cold bend and fatigue specimens are to be made, shall be cut into pieces 9 in. by 30 in. (see Fig. 11).

(e) The plates from which impact specimens are to b made shall be cut into pieces 30 in. by 30 in. (see Fig. 14).

Notes.—A power shear may be employed for cutting these plates if they are left flat. Pieces whose dimensions are within ½ in. of the required size will be satisfactory.

6. *Arrangement of Pieces for Welding.*—(a) All welds are to be made across the grain, that is the welded joint is to be at right angles to the direction of rolling. Fig. 13 shows the correct arrangement of the pieces for the test welds to be used for the physical tests, but in Fig. 14, which shows the arrangement of pieces for the impact test, pieces such as J-1 and J-2 should be taken for a test weld instead of J-1 and J-9.

(b) Preparatory to making a weld, one 30-in. edge of each piece will be bevelled at the angle preferred by the applicant. If he has no preference, the angle of the bevel shall be 30 deg. as shown in Fig. 12. The bevel is not to be carried through to the bottom edge but only to within $\frac{1}{16}$ in. of the bottom edge. In other words, the ends of the pieces to be welded are not to be bevelled to a sharp point, but $\frac{1}{16}$ in. of the original square edge will be left at the bottom of the Vee.

(c) For welding, the pieces shall be placed horizontally with their under surfaces raised approximately ½ in. above the supporting surface. The bevelled edges shall be placed parallel and separated ¼ in.

(d) The weld shall in all cases be of the type known as a double bevel.

7. *Welding of Pieces.*—(a) The pieces which shall be dry and free from rust and foreign substance, shall be "tacked" at each end and in the middle of the joint by welding the plates at each of these places for about ½ in.

(b) After "tacking" the weld shall be completed by working continuously from one end of the joint to the other. The welding material shall be added in at least two layers, and when completed the surface of the weld shall be at least flush with, and not more than ¼ in. above the upper surface of the plate. The width of the weld at the top shall not be greater than 1½ in. All welding shall be done from the open side of the Vee.

(c) After each layer of a weld is completed, it shall be inspected by the authorised representative. If

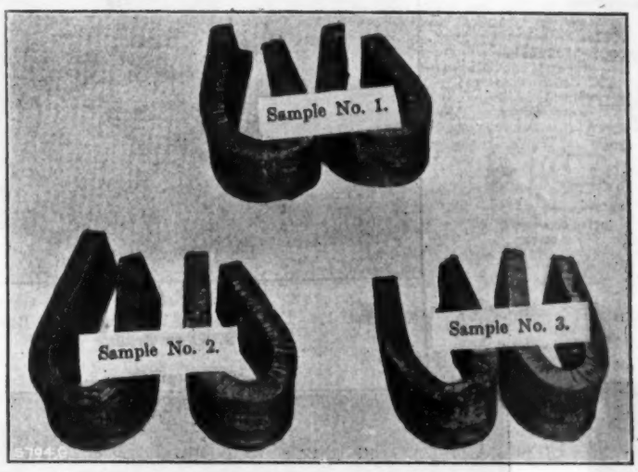


FIG. 15. BENDING TESTS OF GAS WELDS.

TABLE V.—WIRT-JONES TESTS OF ¼-IN. ARC-WELDED SHIP PLATES.
(Samples Not Machined.)

Test Number.	Current in Amperes. A.C.	Current in Amperes. D.C.	Diameter of Elec. in In.	Current Density, Amperes per Sq. In.	Tensile Tests. Ultimate Lb. per Sq. In.	Tensile Tests. Per Cent. Elongation in 2 In.	Electrode. Cov.	Electrode. Bare.	Make of Electrode.
20	175	—	0·125	14,275	66,480	11·0	C	—	E. A. C. and W. Co.
22	160	—	0·125	13,008	66,400	9·0	C	—	E. A. C. and W. Co.
19	150	—	0·125	12,195	65,400	6·0	C	—	Quasi.
5	—	145	0·156	7,554	52,280	7·0	—	B	Am. S. and W. Co.
25	136	—	0·156	7,085	47,800	4·0	—	B	Roebling
3	—	115	0·156	5,891	65,470	13·0	—	B	Am. S. and W. Co.
27	—	110	0·125	8,943	48,200	7·0	—	B	Roebling.
16	—	90	0·134	6,381	58,740	5·2	C	—	Quasi.
18	90	—	0·134	6,381	61,760	11·0	C	—	Quasi.
15	—	90	0·134	6,381	57,340	8·0	C	—	Quasi.
23	—	85	0·125	6,910	57,060	5·0	—	B	Roebling.

unsatisfactory, a new test weld shall be substituted and a report made of reasons for rejection.

8. *Number of Test Welds.*—(*a*) The welds will be made by three skilled operators, two of whom will be furnished by the applicant and one by the Welding Committee.

(*b*) Each operator shall make one 30-in. weld for the tensile, cold bend and fatigue tests (see Fig. 12, page 818) using direct current and a similar weld using alternating current. For these tests, therefore, six (6) test welds will be required for each sample electrode.

(*c*) Each operator shall also make one 30-in. test weld for the impact test (see Fig. 14, page 818) using direct current and a similar weld using alternating current.

observations shall be recorded by the authorised representative during the welding operations:

(*a*) Trade name or other identification mark of the electrodes.

(*b*) Complete description of the electrode.

(*c*) Sufficient description to identify the welding apparatus or system employed.

(*d*) Identification marks on the pieces consumed being welded.

(*e*) Name of operator.

(*f*) Kind of current (*i.e.*, direct current or alternating current); if direct current, polarity, and if alternating current, frequency.

(*b*) Specimens shall be cut from each test weld reserved for physical tests as follows:

1. *Three Tensile Specimens.*—These shall be machined to a uniform width of 1·5 in., unless a weld of great strength makes it necessary to leave shoulders at the ends, in which case the standard A.S.T.M. test specimens for sheet iron and steel shall be prepared.

2. *Three Cold Bend Specimens.*—These shall be machined to a uniform width of 1·5 in.

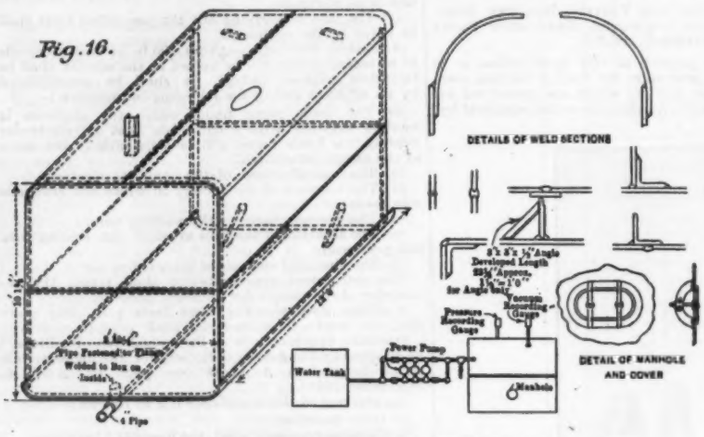


FIG. 16. OUTLINE AND DIMENSIONS OF ARC-WELDED STEEL BOX.

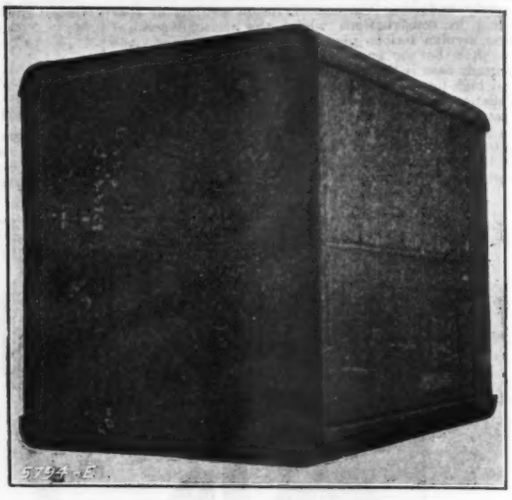


FIG. 17. ELECTRIC-ARC WELDED STEEL BOX OF ¼-IN. TANK STEEL.

FIG. 18. ELECTRIC-ARC WELDED BOX, UNDER 22-INS. VACUUM, SHOWING TOP SIDE DEPRESSED.

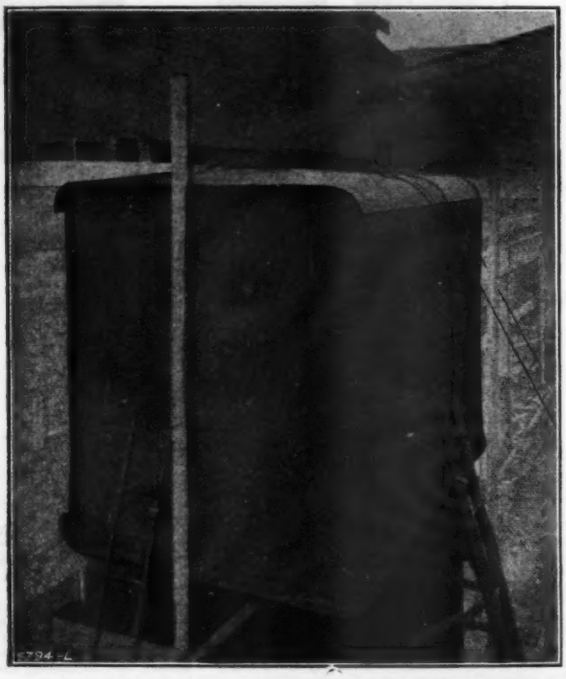


FIG. 19. ELECTRIC-ARC WELDED STEEL BOX UNDER 15 LB. HYDROSTATIC PRESSURE. ONE PHASE OF THE BREATHING TEST.

For impact tests, therefore, six (6) test welds will be required for each sample electrode.

(*d*) If, however, the applicant intends his electrode for use with only one kind of current, that kind only shall be used in making the welds. In that case only three (3) test welds will be required for (*b*) and for (*c*) instead of six (6).

9. *Arrangement of Conductors.*—(*a*) One of the conductors shall be attached to a clamp which will be fastened to both pieces at the end of the joint opposite that from which work is started.

(*b*) For direct current work, the electrode shall have the polarity desired by the applicant. In the absence of any preference on his part, the instructions of the authorised representative shall be followed.

10. *Welding Data.*—The following information and

(*g*) Electrical quantities as follows: arc volts (both open and closed circuit), arc current and arc watts.

(*h*) Room temperature and humidity.

(*i*) The opinion of the authorised representative of the working quality of the electrode. This statement to include a description of any sputtering, boiling or other noticeable peculiarities.

(*j*) Elapsed time per weld.

(*k*) Weight of electrode consumed per weld.

(*l*) Any other information which will assist in determining the performance of the electrode, such as a photograph of at least one weld, &c.

11. *Preparation of Welded Plates and of Specimens for Physical Tests* (see Fig. 13, page 818).

(*a*) Each test weld shall be machined down on both sides to about the surface of the plate.

3. *Six Fatigue Specimens.*—These shall be machined to about ¼ in. diameter and 10 in. long. (The exact dimensions are to be determined by experiment.)

12. *Physical Tests.* (*a*) *Tensile Strength.*—Each of the three specimens shall be tested in accordance with the practice recommended by the A.S.T.M. and shall include the determination of the tensile strength, yield point (by drop-of-beam method), reduction of area and total elongation after rupture in 2 in. and in 8 in.

(*b*) *Cold-bend Test.*—This test shall be made by placing the specimen on two rollers with the apex of the Vee upward and midway between the rollers and loaded at the centre of the span thus formed by a cylindrical surface having a diameter of ½ in. This surface shall bend the specimen downward between the rollers until a fracture appears on the lower side of the specimen

when loading shall be stopped and the angle noted through which the specimen has been bent.

(*c*) *Fatigue Test.*—Each of the six specimens shall be tested in a special rotating type of machine similar to that used by Lloyd's Register of shipping. (Exact details to be determined by experiment.)

(*d*) *Impact Test.*—Each impact-test specimen shall be placed on supports 18 in. high and 2½ ft. apart. A spherical weight of 500 lb. shall be allowed to fall freely through a distance of 10 ft. striking the weld which shall be at the centre of the span. The apex of the Vee shall be upward.

(*e*) *Test of Original Plate.*—In order to establish the physical properties of the unwelded plate, tensile, cold-bend and fatigue tests shall be made on a sample selected at random from the pieces used for the test welds but before such welds are made.

Optional Tests.

The following tests are optional with the applicant, but the Welding Committee considers that they give information of great importance and recommends that they be made in order to make the report on the electrode more complete.

13. *Chemical Analysis.*—A chemical analysis shall be made of:

(*a*) The original plate in one test weld selected at random.

(*b*) The metal at the centre of one test weld selected at random. If test welds are made with both direct current and alternating current, an analysis shall be made from one weld of each set.

14. *Photomicrographs.*—Photomicrographs shall be made of one specimen weld selected at random as follows: (If test welds are made with both direct current and alternating current, photomicrographs shall be made of one weld of each set.)

(*a*) At centre of weld.
(*b*) At juncture of weld and original metal.
(*c*) In adjacent original metal.
(*d*) Cross section of electrode.
(*e*) Longitudinal section of electrode.

APPENDIX B.

WIRT-JONES TESTS OF ARC-WELDED HALF-INCH SHIP PLATE.

In Tables IV (page 818) and V (page 819) are set forth the results of the tests carried out in 1918 on arc-welded ½-in. ship plate by the Welding Research Sub-Committee. The plates with which the welds were made had their edges prepared with a 45 deg. double-Vee. The welds were made by a dozen different concerns. In each instance the operator employed whatever conditions were considered most suitable. Several types and sizes of electrodes including both bare and covered, were used. While in the majority of cases direct current was employed, alternating currents of 25 and 60 cycles are also represented in the series. The number of layers and the current employed and, indeed all the conditions, were left to the discretion of the individual operator. The length of the weld was 8 in. After the welds were made, the plates were cut up by the Wirt Company (thanks to the courtesy of Mr. Charles Wirt). The tests were made at the Bureau of Standards under the direction of Professor H. L. Whittemore. The tensile tests were made on specimens with a cross-section of 1 in. by ½ in. Specimens with the weld machined have the projecting metal planed off so that the welded portion is smooth, and of approximately the same cross-section as the remainder of the specimen. For the specimens with the weld not machined, no record was made of the added cross-section due to the projecting material.

The cold bend specimens were 1 in. by ½ in., and were bent around a mandrel of 1·5 in. diameter. The results of the tensile and bending tests for the machined samples are given in Table IV. Those for the samples which were not machined are given in Table V.

APPENDIX C.

BENDING TESTS OF GAS WELDS.

Too late for inclusion in the body of this paper there has been brought to the author's attention some gas welds made under the direction of H. I. Walsh, of the Newport News Shipbuilding Company, which have withstood very severe bending tests before failing. The specimens are shown in the photograph in Fig. 15 (page 819). Three pairs of specimens welded with three kinds of electrodes are shown. These specimens show much greater ductility than those shown in Fig. 5 (page 785).

APPENDIX D.

ARC-WELDED STEEL BOX.

Mr. R. E. Wagner has prepared the following description of a large steel box, arc welded with bare electrodes at the Pittsfield Works of the General Electric Company. The box was built and tested in the latter half of 1918. It was made of ¼-in. thick tank steel, and its dimensions were 12 ft. by 10 ft. by 9 ft. The total weight was 16,000 lb. The welding was done with 75-volt direct current. This box contained eleven different varieties of welds. Its general dimensions and the types of welds used are shown in Fig. 16. No rivets were used in its construction.

The principal objects to be gained in the construction of this box were:

1. Could a structure of this character be made close to drawing dimensions and without excessive distortions and warping of plates and parts?

2. Would the structure be strong and capable of withstanding severe shocks and distortions without serious ruptures?

3. What are the detail costs and time required to build such a structure?

It was found that if proper allowances are made for contraction and expansion, especially where plates are butted and welded, the resulting plate will show very little warping. The maximum variation of the sides from a plane was 1¼in. The general appearance of the box when completed is shown in Fig. 17.

The box, when finished, was strong and well built. All joints had a smooth workmanlike finish. A number of incipient leaks developed when the box was first filled with water, but these were closed by hammering. The box was subjected to a hydrostatic pressure of 43 lb. per square inch, and, after it had been severely stressed and distorted, it ruptured at a corner, the break starting at the top and opening the entire corner. This corner was afterwards repaired (as shown in Fig. 18), and the box was subjected to a "breathing" test, consisting of alternate applications of 15 lb. pressure, Fig. 19, and 22 in. of vacuum, Fig. 18.

During each cycle of this "breathing" test the top of the tank had a maximum movement of 8 in. from bulge to depression. At the sides the movement was 6 in. Every time that these bottom and top plates moved from bulge to depression, there was a sharp snap of the plates as they moved from "arch in" to "arch out." These sudden changes in form subjected the welded joints not only to bending stresses but to severe snapping stresses. At the end of the twelfth cycle a break occurred in a double-bevel weld. At one end the break left the weld and went into the solid plate. This break was patched, and the "breathing" tests were resumed. The next break which occurred after the 235th cycle of operation extended 24 in. into the solid end plate as well as 17 in. along a weld. This break will be repaired and the tests will be resumed.

The following cost data is of interest:

	Dols.
Welding	151·00
Fabricating and assembling	134·00
Blacksmithing	24·00
Testing and supervision	50·00
Welding wire	30·00
Steel plate	651·00
Total cost	1040·00

Total pounds of wire used	334
Total pounds of wire deposited and lost	299
Total scrap ends of wire	35
Total feet of welding	501
Total hours of welding	165
Total kilowatt hours	1,011
Per cent. scrap ends of wire	11
Wire deposited per foot (pounds) ...	0·6
Kilowatt hours per pound of wire deposited	3·4
Average feet welded per hour ...	3·0
Average kilowatt hours per foot of welding	2·0
Per cent. of time welder is welding ...	60
Diameter of welding wire, inch ...	5/32

Six different welders obtained the results noted, which are representative for a job of this character.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting of the Physical Society of London, held on May 9, 1919, at the Imperial College of Science, Professor C. H. Lees, F.R.S., president, in the chair, a demonstration of "*A New Colour Transparency Process for Illustrating Scientific Lectures*" was given by Mr. A. E. Bawtree, F.R.P.S.

Methods of illustrating scientific lectures may be divided into three classes: Blackboard drawings and wall diagrams, experiments and optical lantern slides. The first is unsatisfactory, especially before large audiences; the second entails much preparation and some risk of failure, and is limited in its usefulness; the third method is of far the widest application. For astronomical, microscopic and archæological subjects and for radiographs and other purely photographic records, monochrome photographic slides leave nothing to be desired, but for many purposes colour is necessary. Owing to the large scale of magnification upon the screen, only the crudest washes can be obtained by hand-painting. Processes of natural colour photography are excellent when there is no very fine work which would be destroyed by the grain of the image; but some subjects require definition of microscopic fineness combined with brilliant colouring. It was in order to illustrate a paper before the Engineering Section of the British Association upon a method of banknote engraving that the author devised the process illustrated.

The image is produced in a thin colloid film upon bare glass. Considerable experimenting led to the selection of a range of dyes and mordants by which practically any shade of the most brilliant colouring could be obtained. By suitable insulating films, images in any number of colours can be superimposed and accurately registered with one another. Thus, diagrammatic slides can be prepared in various colours. The passage of a beam of white light through a prism can be shown spreading out into bands of colour, instead of merely initialed lines. Coloured mosaics can be placed in diffusing lantern to show the preparation of additive colours—*e.g.*, red and green producing yellow, more convincingly and brilliantly than with the Maxwell disc.

The process has other applications than the preparation of lantern slides. If a screen of lines ruled in alternate red and green of, say, 250 lines per inch, have projected upon it by means of a lens the image of a screen of similar ruling, but in lines of alternate black and white, the former screen will appear to change colour with a movement of the latter image of only 1/250 of an inch. Thus, this small motion can be rendered strongly visible to the largest audience. In this manner compressive or tensile strain in a rod or the expansion of a rod with heat can be shown. By means of a balance beam fitted with a scale pan at one end and a bell crank at the other end, very small pressures—say 10 milligrammes—can be made to act upon a heavy body; for example, a hollow leaden ball of 10 kg. weight just floating in water. By such an apparatus, combined with the two screens, the laws of fluid friction and of motion can be beautifully illustrated. In moving 1 in., the ball will cause the screen to change colour 250 times, and these colour changes can be plotted against time in a variety of experiments. Numerous other applications of the method preparing any form of colour transparency will doubtless suggest themselves to lecturers, and the process should place a useful additional means of demonstration in their hands.

A paper, entitled "*Absolute Scales of Pressure and Temperature*," was read by Mr. F. J. W. Whipple, M.A. The paper urges the general use of the new scales of pressure and temperature which have been adopted by meteorologists. In the pressure scale the fundamental unit is the bar, the pressure due to 1,000,000 dynes per square centimetre. The practical unit is the millibar. The temperature scale is that known as the pseudo absolute scale, obtained by adding 273 to the centigrade scale. The author, however, considers that it would be advantageous to use the "Integral Freezing Point" scale, in which the interval between absolute zero and the freezing point of water is divided into 273 deg. exactly.

Discussion.—Dr. C. Chree thought the millibar was a convenient unit for practical use. He did not think too much stress should be put on the existing estimates of the absolute zero, which might be in error by more than was expected. He remembered how at one time the temperature 62 deg. F. was fixed in reference to a particular Kew thermometer made of an unusual kind of glass, and used horizontally although it had been calibrated vertically.

Mr. F. E. Smith said that in reference to the remark about National Physical Laboratory certificates, these certificates always referred to the hydrogen scale, and there was in this case no ambiguity as between absolute or pseudo absolute.

Mr. Whipple said he had not noticed that any of the certificates he had seen specified the zero. Professor Lees asked if the author was definitely recommending the use of the I.F.P. scale rather than the other. To this Mr. Whipple replied in the affirmative. Professor Lees then said that it was easy to get the correction from the pseudo absolute to the absolute centigrade scale by simple addition; but if the I.F.P. scale were adopted the conversion would be somewhat difficult, especially if the accepted value of absolute zero had ever to be revised.

A paper, "*On the Transmission of Speech by Light*," was read by Mr. A. O. Rankine, D.Sc. Light from a point source is collected by a lens of about a metre focus, and an image formed on a small concave mirror, which is attached to the diaphragm of a gramophone recorder. The light diverges and passes through a second similar lens, which projects it to the distant station. Two similar grids are mounted, one in front of each lens. An image of the first grid is superposed on the second by reflection in the concave mirror. When the latter oscillates under the vibrations of speech, the dark spaces of the image move over the openings of the second grid, thus producing fluctuations of the intensity of the beam. The light is received by a collecting lens and focused on a selenium cell in circuit with a battery and telephone receiver.

Discussion.—Mr. E. H. Rayner thought it a pity that no advantage had been obtained by using a searchlight reflector. At present these mirrors were moulded, and the errors in focus were considerable. Sometimes, however, a really good one could be found by selection. Professor Fortescue admired the ingenuity of moving the image of a grid instead of the grid itself, as with any form of microphone the available forces were small. It appeared that at present very little was known about the selenium cell. It was desirable that physicists should investigate this more fully. Professor Porter commented on the author's thorough investigation of the conditions governing the design. Mr. C. C. Paterson asked how much of the sensitivity of the selenium cell was actually effective at these frequencies.

Dr. Eccles called attention to the historical association of phototelephony with University College, London. Graham Bell's father was a member of the Physics Department at University College some forty years ago, and he himself, there is reason to believe, may have begun there his experiments on phototelephony. The author of the present paper had worthily upheld the traditional position of the college in this subject. With regard to the present apparatus, the speaker took the opportunity of testifying to its excellent performance in the field. He had witnessed successful trials over a distance exceeding half a mile, and found the articulation much more perfect than is usually achieved with carbon microphones. There are two main types of phototelephony, one in which the source of light is kept constant and the flux of light along the beam modulated by the voice, and one in which the emission of light from the source is modulated. Dr. Rankin's method belongs to the former class. The well-known arc method is illustrative of the latter class, and has been stated to have been used on ships of the German Navy at sea over distances of 7 miles. Its chief disadvantage relative to the first type lies in its poor articulation (so far as it has been developed); its advantage arises mainly through the smallness of the influence of the tremors and shocks always present in a ship, for instance, against which

the mobile mirror in Dr. Rankine's apparatus could be protected only with great difficulty. Nevertheless, as an improvement on Graham Bell's grid method, Dr. Rankine's conception of moving a light mirror instead of a heavy grid was an elegant and practical step.

Mr. T. Smith expressed his admiration of the manner in which the difficulties of the problem had been overcome. He was not in agreement, however, with much the author had said as to the conditions of efficiency. He explained how, so long as the aperture of the projecting lens appeared filled with light, as seen from the receiving station, aberrations of the projecting system were of no consequence. On the other hand, the correction of the receiving system becomes of importance when the image of the aperture of the projector approaches its maximum useful size. He thought there might be advantages in dispensing with the grids altogether and varying the intensity by the movements of a small steeply graduated absorption wedge situated near an image of the light source.

Mr. A. P. Trotter described some experiments which he had been invited by the Admiralty through Dr. Eccles to carry out. He did not know who the inventor was, or if more successful results had been obtained elsewhere. His own results were not worthy of more than a place in the discussion on Dr. Rankine's paper. Almost all the apparatus had been provided by Dr. Eccles. Small lamps having tungsten filaments about 5 mm. in length were filled with hydrogen or with mixtures of hydrogen and nitrogen. The best were filled with hydrogen at pressures from 200 mm. to 600 mm. below atmospheric. A circuit was made through a microphone and a lamp, either direct or through a transformer, and the filament responded to the undulations sufficiently to reproduce speech when the light was concentrated on the selenium cell. The utmost distance that he could transmit speech with lenses 76 mm. (3 in.) diameter was about 2 m. The cells were about 8 mm. square.

Dr. Eccles said that the method of light telephony just alluded to was an invention of his own, which he had hoped to describe at a future date along with two or three other novel methods. The idea underlying the method alluded to is to obtain a glow lamp with so fine a filament that its temperature and light emission could follow acoustically produced alterations of filament current. The best telephonic results were obtained when the lamp bulbs were filled with hydrogen. After the method had been shown feasible for speech frequencies, some of the early test lamps were sent to Mr. Trotter, and he was asked to measure, if possible, the actual fraction of a second taken by the filament to rise to and fall from its maximum brilliancy after a current was switched full on or right off. This he accomplished very successfully. Regarding Mr. T. Smith's suggested use of a black glass wedge moved by the voice to produce modulation of the flux from a steady source, the speaker said he had used and found excellent a similar and even simpler method, in which a sewing needle fixed to the sound box of a phonograph had its shadow projected by aid of an obvious optical system upon the distant selenium; the acoustic vibrations of the needle caused a magnified motion of the shadow which covered and uncovered the selenium correspondingly, and gave as the result very perfect articulation in a telephone receiver in series with the selenium.

Mr. F. E. Smith asked to what extent the cells were screened, as the sensitivity varied greatly with the total illumination of the cells. He thought that the method might be of great use in the development of speaking and singing cinematograph pictures, as the record could be in the form of a second film working beside the other, producing variations in a second beam of light in exact synchronism with the picture. A receiving system as in Dr. Rankine's arrangement would convert these fluctuations into speech.

Mr. P. R. Coursey suggested the use of a polarised beam of light modified in intensity by electromagnetic rotation.

The author, in reply, said that no great constancy was required in the behaviour of the cells. Those used were about ¼ in. square, and the image was purposely spread somewhat in order to ensure that the sensitive area was covered. For rapid vibrations such as those of speech he did not expect more than a thousandth of the sensitivity of the cell was realised. He thought screening improved the performance of the cells.

AMERICAN MACHINE TOOLS FOR EUROPE.—A proposition is now under consideration by the War Department, Treasury Department and State Department of the United States Government, says *Canadian Machinery*, which may solve the problem of re-equipping many Belgian and French factories, and at the same time result in quick disposal of about 75,000,000 dols. worth of surplus machine tools which the War Department has on hand. It is proposed that this Government turn all of these tools over to Belgian and French manufacturers, the necessary credits to be established through inter Government financing. The disposal of these tools in the United States has been arranged for up to a certain point, but it is realised that the problem is a huge one, and the disposal of the equipment in the manner indicated would be an easy and speedy solution, although it is admitted it would ruin the prospects of many exporters of machine tools who have in prospect considerable Belgian and French business. A great deal of machine-tool business should come to America from Belgium, especially as that country has placed an embargo against the importation of German tools, and this embargo, it is understood in New York, will not be removed even after the peace treaty is signed. Practically the only competition America will have, therefore, will be from England.

THE PRESENT POSITION OF GERMAN INDUSTRY.

SOME balance-sheets recently published already show something of the change which has come over German industry during the last few months. Thus the Krefeld Steel Works only show 24,542 marks net profits for last year, as compared with 2,928,088 marks for the previous year, when a dividend of 12 per cent. was declared. For last year a dividend is, of course, out of the question. Reconstruction work could only be carried on at great cost, and it was necessary to draw 1,500,000 marks from the reserve. The prospects for the present year are not favourable. The Louis Busch Metal Goods Company, in Mayence, which had taken up the manufacture of war materials during the last few years, has stopped payment and is indebted to the Exchequer to the extent of 2,000,000 marks. The Berlin General Omnibus Company carried only 7,804,862 passengers in 1918 compared with 33,166,756 in 1917 and 72,152,864 in 1916. The year's working thus results in a loss of 501,222 marks. To cover this, the balance of the legal reserves has been entirely absorbed, and 375,778 marks has been taken from the traffic reserve, which is also much reduced. A sum of 802,425 marks, derived from different transactions not shown in the balance-sheet, however, was added to the reconstruction reserve, which now amount to 4,103,093 marks. Higher wages and shorter hours necessitated an increase in fares from February 1, 1919. These now stand at 20 pfennig per section, and 30 pfennig for the whole journey for horse omnibuses. For motor 'buses the fares are 25 pfennig for distances up to 3 km., 30 pfennig for distances up to 7·5 km., and 35 pfennig for longer distances. The increased fares, however, do not cover the increased costs of working.

Although the strike movement in the Ruhr district seems to have subsided, it has wrought serious havoc for the men themselves and even more so for the mining and other concerns. Stoppage, and in some cases bankruptcy, are the outcome of this state of affairs. The Blankenburg Company, for instance, has called a general meeting with a view to closing down completely, as the company is threatened with complete ruin. A sum of 35,000,000 marks has been lost since the beginning of the revolution in November. The Bochum Mining Company is actually bankrupt, having lost 899,462 marks during the last quarter of 1918, 425,000 marks in January of this year and still more during the following months. About 90 per cent. of the company's shares (the capital is 6,000,000 marks) are held by the Becker Steel Works, which will now take over the concern. The effect of this is likely to be even more serious for the 10 per cent. of the shareholders outside this concern.

The Harpen Mining Company, which owns mines in various parts of the Ruhr district, reported early in the present year, before the most serious strikes commenced, that they had to reckon with an aggregate increase in the cost of production of 73,000,000 marks for the year. This would amount to 86 per cent. of the company's share capital of 85,000,000 marks. The 73,000,000 marks were made up of 28,000,000 marks increase in wages, while the remaining 45,000,000 marks were accounted for by the reduction in working hours and diminished energy on the part of the workers.

Similar reports come from other industries. The Continental Caoutchouc and Gutta Percha Company states that their increased cost of production for January amounted to 5,138,318 marks, of which 1,678,352 marks was due to higher wages and the balance to decreased work put in.

The Adler works estimate the increase in cost of production since the beginning of the revolution at 86 per cent. of the amount previously paid for a year in wages. Of this increase over 33 per cent. would be due to increased wages. The legally decreased working hours are responsible for a further 12½ per cent. and 40 per cent. is accounted for by the smaller amount of work done after the revolution. Another concern states, that in January they only put in half the amount of work they did before the revolution. In other places, however, the shorter hours seem to have been responsible for a somewhat increased production in a given time.

In Upper Silesia more than half of the blast furnaces have been closed down, and more will soon have to cease working owing to shortage of ore; consequently the production of pig-iron has fallen to an unprecedentedly low figure.

The Heinrich Coal Mining concern which paid a dividend of 400 marks per share for the last quarter of 1918, has been unable to pay any dividend for the first quarter of the present year.

AMERICAN SHIPPING OUTLOOK.—The most uncertain factor in the American shipping situation, says *Commercial America*, is the amount of tonnage which will be required to carry out the European food-relief programme, for it is certain that the bulk of the available shipping will continue to be assigned to this food service until the crisis overseas has been passed. Officials of the United States Shipping Board naturally are reluctant to make any definite promise as to when it will be possible to divert shipping from food carrying to the ordinary mercantile trades. A certain satisfaction is to be derived from the fact, however, that both E. N. Hurley, chairman of the board, and J. R. Rossetter, in charge of the operation of the vessels under the board's control, have stated, after a careful survey of the situation in co-operation with those in charge of the relief work, that by the first of July it should be possible to assign vessels to the commercial routes in constantly increasing numbers.

CATALOGUES.

Electric Lighting.—A sixth edition of their useful little handbook on electric lighting connections has been issued by Messrs. A. P. Lundberg and Sons, 477, Liverpool-road, Islington, N.7.

Shutters.—Messrs. S. W. Francis and Co., Limited, 64, Gray's Inn-road, W.C. 1, send a folder announcing that they are now ready to execute orders for revolving shutters and other shop fittings.

Belting.—A priced list of belting in leather, balata and cotton comes from Messrs. Matterson, Huxley and Watson, Limited, Coventry, who stock a considerable range of plys and widths from ¾ in. to 8 in. broad. Some useful power transmission tables are added.

Blow Lamps.—A new British made paraffin blow-lamp is shown in a catalogue issued by the Kitson-Empire Lighting Company, Limited, Stamford. It is made in two sizes of 1 pint and 5 pint capacity. The design is strong and well balanced, and the total weight reasonable.

Instruments.—The Cambridge Scientific Instrument Company, Limited, send a catalogue showing various indicating and recording instruments for steam plant; thermometers in variety, draught gauges, CO_2 recorders and calorimeters. Also a list of firms using their instruments with illustrations of the plant served by them.

Milling Machinery.—Rotary fine crushers, crushing rolls and screening machines are the subjects of three catalogues from the Sturtevant Engineering Company, Limited, 147, Queen Victoria-street, E.C. Each of these are made in four to six sizes, and the machines are largely used in series in the order named. They are strongly made and well protected.

Steel Construction.—An American catalogue of steel structures for bridges, buildings, storage tanks, riveted steel pipes and ships comes from the McClintie-Marshall Corporation, 50, Church-street, New York, U.S.A. These are made at the works and sent out ready for assembling. Views are shown of many well-designed structures.

Electric Vehicles.—A system of battery-charging equipment is illustrated and described in a special catalogue received from the Igranic Electric Company, Limited, 147, Queen Victoria-street, E.C. It is made up of a number of unit sections with self-contained rheostats. These sections, up to six in number, are fitted in vertical series in a frame, and a number of frames bolted together to make up any required size of switchboard.

Jib Cranes.—A catalogue of nearly 100 pages, all well filled with illustrations and text concerning travelling jib cranes alone, comes from the Brown Hoisting Machinery Company, Cleveland, Ohio, U.S.A. The illustrations are exceptional good and, taken together, show a remarkably large range of special adaptation of one form of machine. In nearly all cases sufficient data of capacity are given with each illustration, and there is a general account of the methods of construction which is of some technical interest.

Gas Furnaces.—The series of furnaces shown in a catalogue received from the Dowson and Mason Gas Plant, Company, Limited, include an oven for temperatures of 100 deg. to 1,350 deg. C., made to any required length and any width from 1 ft. to 14 ft.; a double chamber rivet-heating furnace for low pressure air; an oven on four legs for temperatures up to 1,100 deg. C. for main-pressure gas and atmosphere pressure air; and a high-speed steel hardening oven on the same lines in six sizes, from 5 in. to 14 in. wide. These all have silent burners.

Ball and Roller Bearings.—A catalogue of ball and roller bearings, journal and thrust, issued by the Hoffman Manufacturing Company, Limited, Chelmsford, is commendable for its extreme compactness with clear type or figures and sufficient illustrations. All necessary sizes and fitting limits are given and every item is priced. A useful little case of gauges is issued by this firm consisting of 15 rollers, such as are used in the bearings, hardened, ground and lapped to within 0·0001 in. of accuracy. The sizes are ¼ in. to 1 in. by $\frac{1}{16}$ in. and 1¼ in. and 1½ in.; both diameter and length are the same measurement.

Electric Safety Lamp.—A miner's electric hand lamp, made by the Fuller Accumulator Company, Limited, Chadwell Heath, Essex, appears to have all the qualities required. Hardly any small thing is so misleading in its apparently rounded simplicity of construction. It has to fulfil a great variety of requirements, and to satisfy the miner and the Home Office mine inspector—critics of such unquestionable ability and severity that nothing is left for others to say if they are satisfied. The weight is 5¾ lb. complete, the maximum light is given for 10 hours, and a reduced light for a further 5 hours. Special charging stands are also supplied.

Locomotives.—The Baldwin Company, Philadelphia, U.S.A., has issued a little "record" booklet in celebration of the completion of its fifty-thousandth locomotive, the number occurring in one of 12 engines of the Mallet articulated 2-8-8-2 type specially designed for an undulating and curved route. The total weight without tender is 191 tons. Very full particulars of the engine are given with an interesting historical account of the company's operations, since its beginning in 1831. An illustration of the "Best Friend," the first locomotive built in America, is somewhat ridiculed in the (quoted) text, and in our opinion unfairly so. The engine was highly creditable to those who designed and built it with the knowledge, materials and tools of their day. The illustration, now much blurred, shows signs of having been an exceedingly clever drawing. This engine ran over 16 miles an hour with four or five cars carrying 10 passengers in each.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-Lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

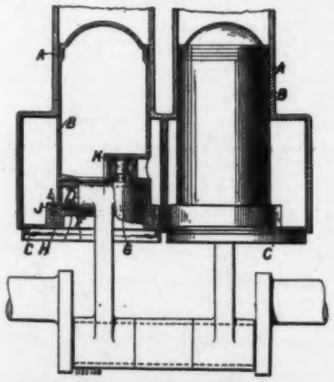
ELECTRICAL APPARATUS.

123,124. W. Williams, Leigh, and Callender's Cable and Construction Company, Limited, London. Electric Cables. (3 *Figs.*) December 12, 1917.—This invention has reference to insulated electric cables of the cab tyre type, comprising a central insulated conductor and a surrounding sheathing of tough rubber compound. The invention has for its object to support, strengthen or reinforce the more or less resilient mechanical protective sheathing of an insulated electric cable of the kind referred to by means of material of a lighter and less expensive character than heretofore proposed. For this purpose, in an electric cable of the kind referred to according to the present invention, the protective sheathing, formed of more or less resilient material such as rubber, gutta percha or equivalent material, but preferably rubber of the hard variety known as cab tyre sheathing, and all hereinafter referred to as hard sheathing, has intimately combined therewith a wrapping of strong textile material, comprising one or more layers thereof, and an outer layer of more or less resilient material of the kind referred

to preferably of the hard rubber type. The wrapping, or each wrapping of textile material, is of a more or less openwork character, or applied in such a manner as to leave spaces or interstices between its component parts so that portions of the adjacent inner and outer hard rubber sheathings between which it is arranged can, during the vulcanising process to which the covered cable is finally subjected, extend through the spaces or interstices therein and firmly unite the adjacent sheathings together. Or the protecting sheathing may comprise three or more concentric layers of resilient material of the kind referred to and two or more wrappings of textile material of the kind referred to arranged between and combined with adjacent layers of the resilient material. *a* is an insulated cable of the kind referred to, having a protective sheathing *b* of hard rubber. *c* is a wrapping of strong textile material wound around the sheathing *b* and *d* is an outer layer of more or less resilient material, preferably of the hard rubber type as herein referred to, applied around the wrapping *c*, the inner sheathing *b*, intermediate wrapping *c* and outer layer *d* being intimately combined with each other as herein described. (*Sealed.*)

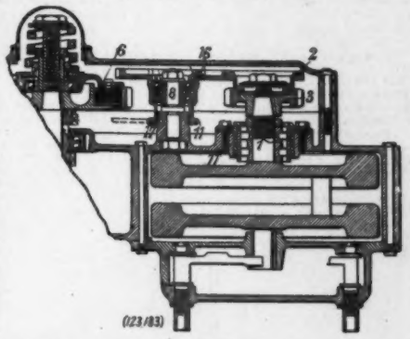
GAS ENGINES, PRODUCERS, HOLDERS, &c.

123,129. P. T. Houston, London. Internal-Combustion Engines. (5 *Figs.*) January 12, 1918.—This invention relates to two-stroke cycle internal-combustion engines of the kind described in Specification No. 3135 of 1917. According to the said prior specification, the engagement between the gudgeon pin for the small end of the connecting rod and the piston, is characterised by the bearings for the ends of the gudgeon pin being so mounted in the piston that, although they reciprocate as one with it, the piston can turn relatively to the said bearings; an extension being provided on the small end of the connecting rod to operatively connect with the piston and effect the turning movement of the latter. The piston hereinbefore referred to is the working piston, and an annular pump piston was described as connected rigidly to the lower end of the skirt of the working



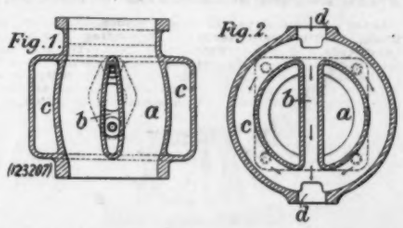
piston. According to the present invention, the annular pump piston is rigidly connected to the gudgeon-pin bearings. A are cylinders, B are working pistons, and C are annular pump pistons. The gudgeon pin D is carried in bearings F, which are formed on a ring G solid with the pump piston C, and raised on the face thereof. The working piston B is mounted so as to be free to rotate on the ring G, and has a flange formed on the end of its skirt. An externally-screwed nut I surrounds the working piston above the flange, and is adapted to be screwed into a ring J formed solid with the face of the pump piston C. The nut I is not screwed hard down upon the flange, and thus the working piston can turn relatively to the pump piston. As described in Specification No. 3,135 of 1917, the connecting rod E is provided with an extension K operatively connected with the working piston B for imparting a turning movement thereto, but it will be obvious that according to the present invention, the pump piston C, while reciprocating with the working piston B, does not turn with the latter, as the pump piston is rigidly connected to the gudgeon-pin bearings F. (*Sealed.*)

123,183. W. F. Lechmere, Greet, juxta Birmingham, and The James Cycle Company, Limited, Greet, juxta Birmingham. Magneto Drives. (2 *Figs.*) February 25, 1918.—According to this invention, the crankshaft carries a spur pinion which engages with a larger spur wheel carried by a stub axle or shaft projecting from a boss cast on the side of the crank-case, this spur wheel being carried by or integral with the sleeve, which also carries a sprocket pinion which drives the magneto. The crankshaft 1 carries a pinion 2, which is secured to the face of the main sprocket driving pinion 3. The main drive is by a sprocket chain (not shown) to the clutch 6. The



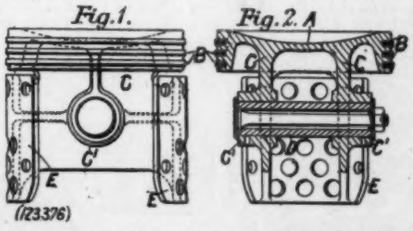
stub axle 8 is secured to the crank-case 11 by a screw which is inserted from the inside of the crank-case and enters the end of said axle, which latter projects outwardly, and carries a sleeve which also carries the inner member of a pair of ball races, all being clamped firmly in position by means of a nut screwing on to the outer end of the axle. The spur wheel 16, which is driven by the pinion 2, is preferably twice the size of the pinion, and it is preferably integral with the sprocket pinion 17, the spur wheel and pinion being formed on opposite ends of a sleeve within which are disposed the outer members of the ball races. The sprocket pinion 17 drives the magneto through a chain and wheel on the magneto shaft. (*Sealed.*)

123,207. J. D. Siddeley, Meriden. Vaporisers for Internal-Combustion Engines. (2 *Figs.*) March 21, 1918.—This invention relates to vaporisers for internal-combustion engines of the type in which a central passage, for the heating medium, passes through the passage for the gas and/or air or mixture thereof. According to the present invention, the passage for the heating element, which may be either hot water taken from the cooling system, hot oil taken from the lubricating system or part of the exhaust gases, is elliptical or approximately elliptical in shape, is so arranged in relation to the chamber *a* through which the gaseous mixture from the carburettor passes



that its transverse axis lies in the direction of the flow of the gaseous mixture through said chamber, the preferred construction being one in which the vertex nearest to the inlet to said chamber is greater than the vertex nearest to the outlet of said chamber, which gives a more perfect streamlike form to the exterior of said passage. This passage is provided with suitable shaped inlet and outlet ports for the connection of the pipes or passages for the heating element. In some cases the chamber *a* may also be heated by an external jacket *e*, in which case the transverse passage *b* runs from one side of said jacket to the other, and the inlet and outlet ports *d*, *d*1, are provided in the exterior of said jacket. (*Sealed.*)

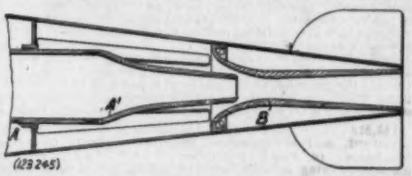
123,376. H. R. Ricardo, London. Pistons. (3 *Figs.*) February 18, 1918.—This invention relates to pistons for internal combustion engines. According to this invention, the piston comprises a flanged head A of such diameter that it is a loose fit within the cylinder with the wall of which it does not come in contact, the flange being provided with grooves in which are piston rings B, and a guide portion which is a sliding fit in the cylinder and comprises two curved members or slippers E,



between which lies the gudgeon pin D. This guide portion is adapted to take the whole of the side thrust from the connecting rod, and each of the curved members is separated by a continuous gap from the adjacent edge of the piston head flange A. Webs C carry members E, and the face of the piston-head disc, with all of which parts the webs are integral. The arrangement of the webs C is such that heat will be so conveyed from the piston head to the slippers as to be distributed equally over the whole surfaces of the slippers. The webs comprise two main members which may or may not be arranged parallel, and are integral with and spring from the face of the piston-head disc, each main portion of these webs being formed with a boss C1 adapted to carry the gudgeon pin D. The two guide members or slippers are oppositely disposed so as to enclose the gudgeon-pin bosses, these slippers being, as mentioned, connected to and formed integral with the webs and, through the latter, connected to the piston head and gudgeon-pin bosses. (*Sealed.*)

GUNS AND EXPLOSIVES.

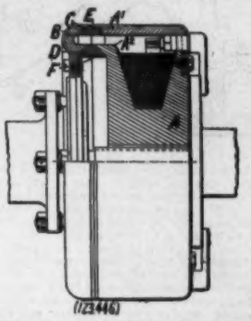
123,245. Vickers, Limited, Westminster, London, M. F. Torazzi, Sandgate, Queensland, Australia, and G. W. C. Webb, Dartford. Torpedoes. (1 *Fig.*) May 16, 1918.—This invention relates to propulsion apparatus of automobile torpedoes of the kind in which a solid self-combustible material is ignited in a tube or chamber and the gases escape through an ejector by which water drawn in from the surrounding sea water is ejected with the gases through the rear end of the



torpedo. According to this invention, the chamber A containing the combustible is of substantial diameter, and is provided with a contracting nozzle A1, the extremity of which extends into the outer or combining nozzle B of the ejector. By this means the gases as they are generated escape through the contracting nozzle at a higher velocity than is obtainable with other apparatus and cause an increased pressure inside the chamber, which is found to improve the combustion of the material and the efficiency of the propulsion. (*Sealed.*)

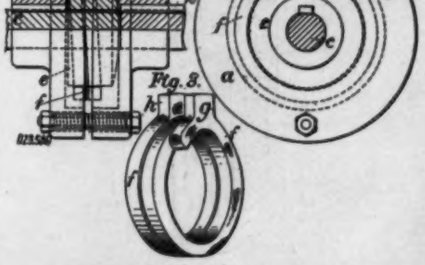
MACHINE AND OTHER TOOLS, SHAFTING, &c.

123,446. W. Langdon-Davies, London, and A. Scarnes, London. Magnetic Friction Clutches. (3 *Figs.*) April 16, 1918.—This invention relates to magnetic friction clutches. A magnetic friction clutch, according to this invention, is provided with a friction member so shaped and proportioned that it tends to remain in its seating in or on the clutch member, without screws or other securing devices, slip taking place at the friction or working face and not at the seating or holding surface. The clutch is shown of the type in which a pot-shaped electromagnet A, having annular poles A1 and A2, works in conjunction with a ring member B, having polar faces corresponding to the poles of the electromagnet. In this particular type of clutch there is



no appreciable amount of relative movement between the members A and B in the direction of the axis of the two shafts to which they are coupled, and the driving pressure between the two members is produced by the flux passing through the magnetic material of which the members are formed. The member B is provided with two annular renewable friction members C and D which co-operate with similar members E and F on the poles A1 and A2 of the electromagnet A. The seating of the friction member C upon the armature B is inclined or conical, the seatings of the members D, E and F being similarly shaped, whilst the surfaces between the members C and E and D and F where slip is intended to take place, are vertical, or in a plane at right angles to the axis of the coupled shafts. (*Sealed.*)

123,506. W. H. Lindsay, Johnstone, Scotland. Flexible Coupling. (7 *Figs.*) November 26, 1918.—The feature of the invention is that each shaft has on it a driving plate, the plates being coupled together by means of a coil, of one or more con-



volutions, the ends of the coil having heads, the one head engaging the one driving plate and the other head engaging the other driving plate so that the power is transmitted from the one shaft through the coil to the other shaft. Within the coil and either arranged freely on one of the shaft ends or

attached to or made one with one of the driving plates, is a central supporting ring, or member, for the coil. The coupling shown comprises two recessed driving plates *a*, *b*, the one keyed to the shaft *c* and the other feathered to the shaft *d*. Against the inner side of the plate *a* a solid metal ring member *e* is fitted, this member being bored to fit freely upon the end of the shaft *c*. Round this member is placed a metal coil *f* having one or more convolutions as desired, the ends of the coil having heads *g*, *h*. These heads fit loosely into rectangular pockets or recesses *i*, *j*, made in the plates *a*, *b*. The coil, which should have spaces left between its convolutions, must be fitted with an easy fit upon the ring member *e*. When the member *e* and coil *f* are placed in position against the face of the driving plate *a*, the driving plate *b* can be fixed upon the shaft *d* in such manner that the head *g* of the coil will enter the recess *i*. Both driving plates are now connected by the coil and, when the shaft *c* is rotated, the connected plates *a*, *b*, drive in the same direction, the power transmission taking place from the plate *a* through the coil to the plate *b* and shaft *d*. The shafts being out of alignment, have their eccentricity counteracted, so far as the power transmission is concerned, by the flexibility and play of the coil, the heads *g*, *h*, of which have a sliding motion within the pockets *i*, *j*, which are made sufficiently large to permit of such movement. The driving plate *b* can slide on the feather *k*, thus permitting a slight axial movement or floating motion to take place without disturbing the coupling, as the plates *a*, *b*, are held in position by bolts fitted loosely in holes in the plates and having spring cushions which tend to keep the plates in position. (*Sealed.*)

123,513. I. E. Mottram, Timperley, W. H. Walker, Stretford, and H. Dawson, Stretford. Drill Grinding Machines. (4 *Figs.*) December 17, 1918.—In drill grinding machines having an adjustable swivelling holder with calliper jaws, the holder proper is formed in one with or attached to a round bar slidably mounted in a swivelling stand, provided with an extension in the form of a round bar passing through a hole in the holder, the feed motion and rest for the rear of the drill also being mounted on the same bar as the holder. The holder proper *a* is mounted on the end of a circular bar *b*, on the underside of which a slot or keyway is formed. The bar *b* is slidably carried by the mount *d* swivelled in the adjustable stand *e*. Said mount is provided with a round extension *f* passing through a hole in the holder *a*, so as to prevent any turning movement of the holder or the bar *b* to which it is attached. The holder *a* can be advanced toward or away from the mount *d* to vary the

Fig. 1.

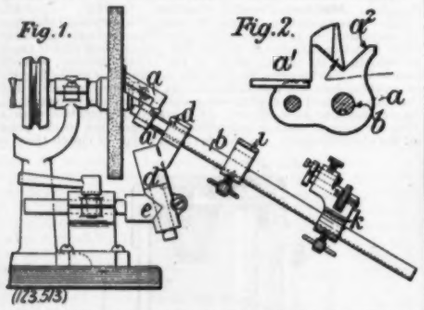


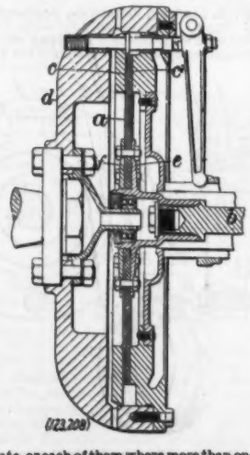
Fig. 2.

(123,513)

distance which the holder overhangs the axis about which the mount *d* swivels, and the calliper jaws *a1*, *d1*, are provided to gauge this distance in the known manner according to the diameter of the drill, a screw-pin being provided to lock the parts in the adjusted position. A V-slot *a2* is formed in the holder *a*, having a stop at the front to form an abutment for the cutting edges of the drill. This stop is ground to a knife edge and the lower part is backed off to a greater extent than the top part, which slopes outwardly so that, while the bottom part presents a very fine edge to accommodate small drills, the stop as a whole is not unduly fragile, as the top part is less keen but yet sufficiently so to accommodate drills of larger diameter, and allow the same to lie correctly in the V groove. At the rear of the mount *d* a rest *i* formed with a V slot is provided to position the shank of the drill, said rest being prevented from turning on the bar *b* by a set pin. Rearward of the rest *i* is a member *k* mounted on the bar *b* in a similar manner. (*Sealed.*)

MOTOR ROAD VEHICLES.

123,208. J. D. Siddeley, Meriden. Clutches for Motor Road Vehicles. (1 *Fig.*) March 21, 1919.—This invention relates to clutches, for the transmission of the power of the engine of motor road vehicles to the transmission gear of said vehicles, of the disc or plate type. According to this invention,

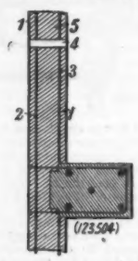


(123,208)

the disc or plate, or each of them where more than one is employed, is made of a material which has radial stiffness and axial flexibility, and the rigid elements of the two parts of the clutch are so proportioned that when same is operating said disc or plate, or discs or plates, operate as a flexible coupling. The single disc *a* of the clutch, which is carried by the driven shaft *b*, and which co-operates with two annular friction discs *c*, *c1*, carried by the flywheel *d* of the engine, is of material having the necessary amount of radial stiffness and axial flexibility, so that said disc not only provides for the transmission of the power but also provides for a limited amount of universal action and a slight amount of end or longitudinal movement. The discs *c*, *c1*, engage the disc *d* by spring pressure, as is usual in this type of clutch, and may be arranged in any suitable manner. The disc *a* is mounted on the shaft *b* by means of a fixed flange *e* and a clamping plate *f*, the size of said flange and/or said plate in relation to the diameter of the annular friction surfaces *c*, *c1*, being such as will, when the two parts of the clutch are in engagement, leave a free annular ring of the disc *a* of such a size as will allow it to flex to the required extent. By varying the diameter of the flange *e* and/or the clamping plate *f* the amount of flexibility of said disc *a* can be varied within the limits, and by the same means said disc *a* can be reinforced to suit the power the clutch is required to transmit. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

123,504. J. C. Grant, Barnes, London. Hulls. (1 *Fig.*) February 11, 1918.—The object of the invention is to obtain an improved method of building a hull entirely of ferro-concrete or ferro-cement. The invention consists in using, instead of wooden or like shuttering as a mould for casting the concrete or cement to be run in or injected, sheets of metal, or canvas hardened, either before or after being placed in position, by treatment with cement or the like. In the case in which canvas mould sheets are used, after their removal, a roughened surface is left that will serve to key with a final layer of cement should a smooth finish be desired. A mould 1 consisting of sheet metal, canvas

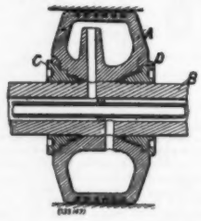


(123,504)

is placed on the inside or on the outside, or, as shown, on both sides of the wire netting or the like reinforcements 2, 3, its distance from the netting being determined by the dimension of distance-pieces 4 placed on the netting. This sheet, when formed of canvas, is then treated with liquid cement, which is allowed to set hard so as to form a mould into which the concrete or cement 5 is injected, preferably by the use of superheated steam. After the cement filling 5 has sufficiently hardened, the mould is stripped off, leaving, when canvas is used, a rough surface which serves to key with a final rendering of cement to give a smooth outer surface should this be desired. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

123,147. Galloways, Limited, Manchester, and H. Pilling, Chorlton-cum-Hardy. Connecting Pistons to Piston Rods. (2 *Figs.*) February 11, 1919.—The invention relates to means for securing a piston to the piston rod by which an adjustment can be effected in the axial position of the piston on the rod. According to the invention, the piston is attached to the rod by two nuts, one on each end face of the piston, and



threaded on the rod so as to allow the piston to be clamped in the required axial position. A is the piston, B the piston rod, C, D, nuts engaging with screw threads on the piston rod. It is obvious that by loosening one of these nuts and tightening the other the axial position of the piston can be adjusted as required. In the example shown the countersunk nuts C, D, are provided with inset surfaces, in order to increase the bearing surfaces between the nuts and the piston. (*Sealed.*)

123,400. The Hon. Sir C. A. Parsons, Newcastle-on-Tyne, S. S. Cook, Newcastle-on-Tyne, and A. P. Bennett, Newcastle-on-Tyne. Turbine Blade Attachment. (6 *Figs.*) February 21, 1918.—The present invention relates to means for securing the last blade of a row of turbine blades which are undercut to fit circumferential projections on the sides of the

Fig. 1.

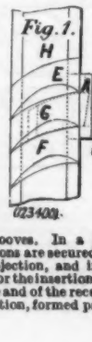


Fig. 2.

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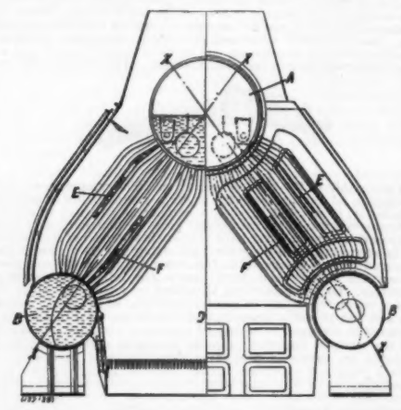
retaining grooves. In a turbine rotor in which blades and spacing sections are secured in a groove by interengaging circumferential projection, and in which a recess is provided in the groove side for the insertion of the spacing sections, the ends of the locking piece and of the recess in which it is inserted are, according to this invention, formed parallel or so inclined to each other over the whole of their surfaces as to permit radial insertion of the locking-piece, their circumferential length being such that the locking-piece overlaps three or more separate blades and packing sections, and is inserted after the last inserted section, and is held in such a manner that it holds the last inserted section positively in the radial direction, while itself is held positively in the radial direction by the adjacent sections, these being held positively in the radial direction by the circumferential groove in which the blades are inserted. The steel locking-piece A, which, in fact, completes the side of the groove H, is made of circumferential length of two blade pitches, the blades, preferably made integral with the packing-pieces, being inserted so that the middle of one of the blades E, F, is opposite each end of the piece A. The recess C, which accommodates the locking-piece A, is of substantially the same length as, but wider than, the piece A, the face opposite the groove H being undercut. The locking-piece A is held in contact with the blades E, G, F, by two filling-pieces B, D, of brass, copper or other suitable material, which are caulked in position, the face of the locking piece on which they bear being serrated as shown, or smooth (*Sealed.*)

123,128. The Stirling Boiler Company, Limited, Westminster, London, and H. J. S. Mackay, Ryde. Steam Generators. (3 *Figs.*) January 12, 1918.—This invention relates to marine boilers of the kind in which lower drums are connected with an upper drum by inclined banks of tubes enclosing between them a furnace space. A feature of the invention consists in the combination in boilers of the kind referred to, of a perfectly symmetrical arrangement of each bank of such tubes about an imaginary line joining the longitudinal axes of the steam drum (and this without the employment of other than cylindrical drums) and an associated mud drum, so that a small number of forms of tube are required for each boiler and a small number of spares only need be carried), with an arrangement of baffles whereby the gases may be caused to traverse the tubes in three passes before flowing off to the outlet

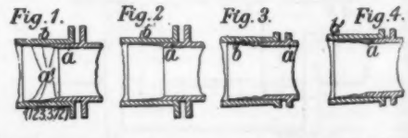


flue. In this connection it might be well to point out that the symmetrical arrangement of the banks of tubes with other than cylindrical drums is not new, nor is, of course, the provision of baffles to provide three passes in each bank in itself new. A denotes the upper or steam and water drum connected with the associated lower drums B by inclined banks of tubes arranged on each side of and enclosing between them the central furnace space D. Each bank of tubes is partitioned into three by two baffles E and F so as to form three passes around the tubes for the gases and hot products of combustion which pass off each side of the boiler to the outlet flue G. The tube holes in the drums A and B are so disposed as to permit the tubes of each bank to be arranged substantially symmetrically about a line indicated by X X, passing through the longitudinal axes of the upper drums A and of the lower drums B, tubes on each side of such line and equi-distant therefrom being of substantially the same length and curvature. (*Sealed.*)

MISCELLANEOUS.

123,372. J. Stone and Co., Limited, Deptford, and T. Drewry, Forest Gate. Expansion Joints. (7 *Figs.*) February 16, 1918.—This invention refers to expansion joints for piping comprising internal and external sleeves adapted to slide telescopically, and liquid or fluid-tight in relation to each other, the internal sleeve being made internally taper to afford a certain degree of elasticity, and so that the pressure of the fluid will cause the tapered part to expand into contact with the inner surface of the outer sleeve and produce a tight joint, notwithstanding axial or other movement of the piping, due to expansion or contraction of the metal of which the piping is made. According to this invention, the taper A1 of the inner sleeve *a* (Fig. 1) is made curved and non-uniform for the whole or a material part of its length instead of being uniform or straight. The end of the spigot is, in some cases, and as shown in Fig. 2, materially reduced

Fig. 1. *Fig. 2* *Fig. 3.* *Fig. 4.*



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by the curved or non-uniform taper, and is then given a uniform or straight taper. The curved tapering is, suitably, in the form of a parabolic or similar curve. Or the taper may be straight or uniform near the end of the sleeve, or from about midway of the taper portion to the end, the rest of the taper being in the form of a parabolic or other suitable curve. Or the interior of the taper portion of the inner sleeve or spigot is of corrugated formation as in Fig. 3, or the corrugations are both internal and external, as in Fig. 4. With an inner sleeve, or any of the constructions before referred to, the sleeve *a* may be made of slightly-reduced diameter externally, and except in the region of the internally-tapered end portion so that, in practice, only this portion, or a part thereof, as in intimate contact with the outer sleeve *b*. Such reduction in diameter may, however, if desired, extend a short distance beyond the region of the taper part. (*Sealed.*)